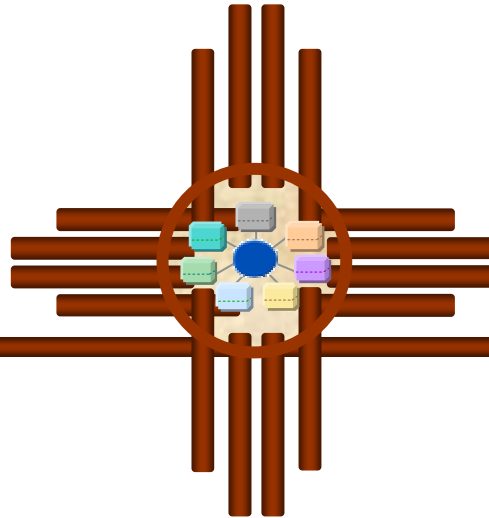


Using a Combination of UML, C2RM, XML, and Metadata Registries to Support Long-Term Development/Engineering



Open Forum 2003 on Metadata Registries

*Knowledge Management and Learning Technologies Track
10:30 – Noon, 23 January 2003*



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Co-authors: MAJ (IDF) Avi Yariv (IDF/CERDEC ESEP) and
Bernard Goren (CERDEC)



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Objective

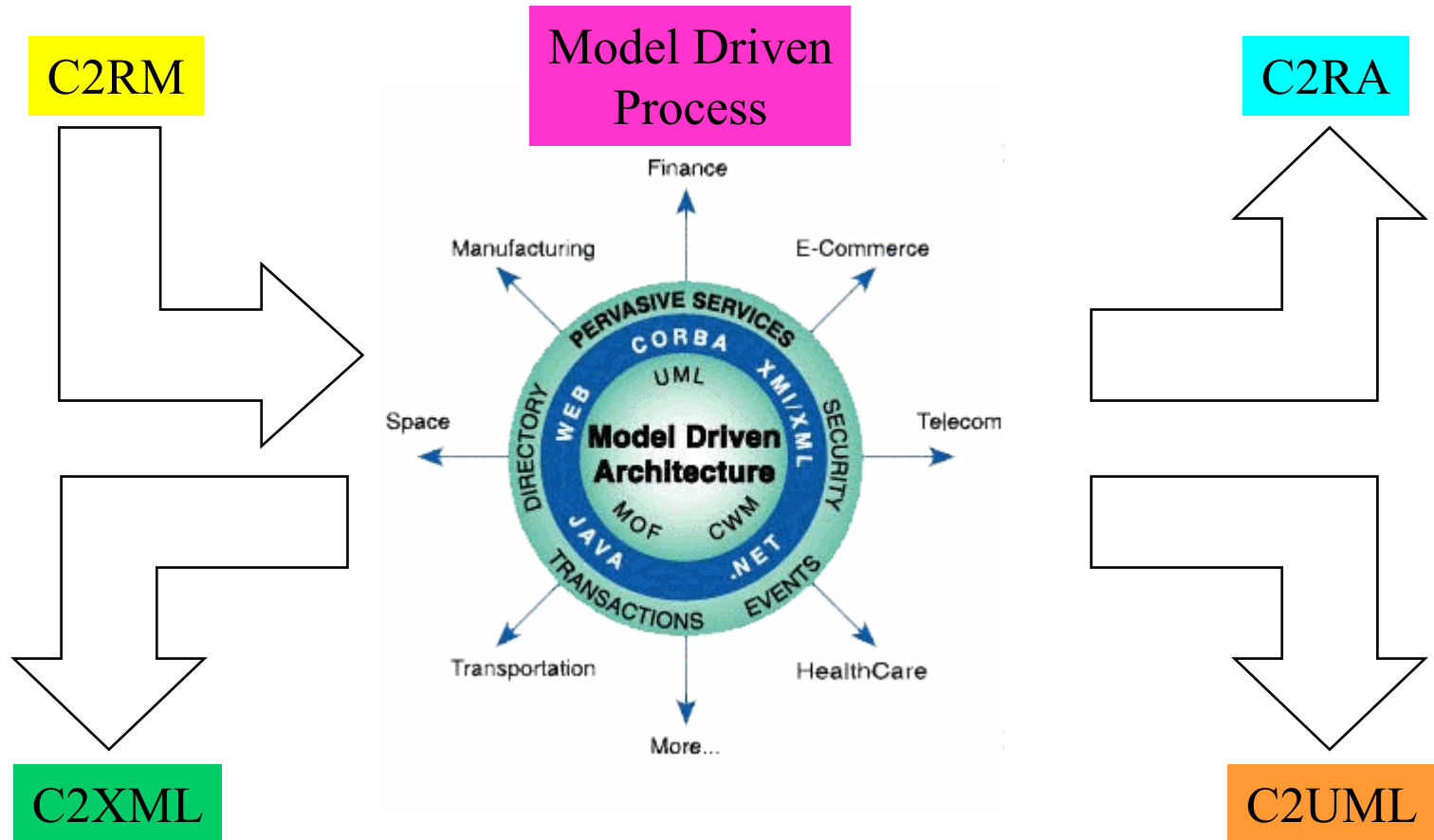
- **To facilitate C2 Architecture and Applications development in terms of a formal language for C2 based upon a C2RM**
- **To derive the rules for analyzing and parsing C2 Products from Natural Language to Machine Language for use by C2 Applications.**
- **To leverage commercial representation and modeling languages such as the Unified Modeling Language (UML) and Extensible Markup Language (XML and associated tools.**

Why Reference Models

- **“ By creating compelling reference models of (domain) knowledge, we lead our organizations into the appropriate conclusions.”**
- **“Reference models are the patterns of the solution for transforming perception into real-world success.”**
- **“Reference models simplify problem solving, so that ordinary professionals can practice their discipline with world-class results”**
- **“Software professionals need reference models in order to understand abstractions”**
- **“20% of adults have the appropriate world-perspective to define abstractions.”**
- **“Reference models (and reference architectures) are necessity in the confusing, rapidly changing technology environment in which we practice”**
- **“Reference models are commonplace in fields of human endeavor”**

See Software Architect Bootcamp, Raphael Malveau and Thomas J. Mowbray, Prentice Hall, 2001, p.238-239

Relationship of C2UML to C2RM C2RA, and C2XML



KEY XML SPECIFICATIONS AND STANDARDS Adapted from Zapthink

Community
Vocabulary

Math & Sciences

Chemistry
(ChemML)
Astronomy
ADML

Math &
Numerics
MathML

Public Sector
Legal
Government
Education
(LegalXML)
(EML)
(SIF)

Publishing
& Print
(NewsML)
(DocBook)

Life
Sciences
(BIOML)
(GEML)

Command
&
Control
(C2ML)

Finance
(ACORD)
(MDDL)
(XBRL)

Customer
Info
(xCIL)
(xCRL)

Land/
Construct'n
(LandXML)
(NVML)

Travel/Food
(RecipeML)
Human
Resources
(HR-XML)

Message-Oriented Specifications

E-Business
Vocabulary

User
Interface

Workflow /
Process

Registry

Service

Messaging

Web
Services
WSXL

WSFL

UDDI

WSDL

SOAP

Rosetta
Net

PIP

PIP

RNIF

Transport Protocol
(HTTP/SMTP/FTP)

eMktPlaces
cXML, xCBL
Universal Business Language (UBL)

ebXML
BPSS

Registry/
Repository

CPP/A

MSS

eCommerce
XML/EDI

Document-Oriented Specifications

Security

Encrypt'n
(XKMS)

Authenticat'n
(XCBF)

Authorizat'n
(XACML)
(SAML)

Privacy
(P3P)

Digital Rights
Management
(XrML)

Content

Content
Mngmnt
(DASL)
(WebDAV)

Content
Syndicat'n
(ICE)
(RSS)

Semantic

Resource
Descript'n
(RDF)

Ontology
(OML)
(OWL)

Tonic
Maps
(XTM)

Presentat'n

Graphics /
Multimedia
(SVG)
(SMIL)
(VRML)

Web
(XHTML)
(LogML)

Voice
(CCXML)
(WML)

Telecommunicat'n
(WML)
(CPL)

Internet &
Computing

Directory
(DSML)
(SPML)

Internat'nalizat'n
(TMS)
(XLIFF)

Device
Interface
(SpecML)

Database
(XQuery)

Instant
Messaging/
P2P
(Jabber)

Core XML
Specifications

Document Linking
(XPath)

Style & Transformation
(XSL & XSLT)

Schema & Validation
(XML Schema)

EXTENSIBLE MARKUP LANGUAGE (XML)

C2 Product Example: Operations Order (OPORD)

**Five-Paragraph Meta-model based upon
FM 101-5, Staff Organization and Operations**

◆ Situation

◆ The Enemy Forces

- ◆ Who are they? What kind of unit is it? What kind of Equipment do they have?
- ◆ Where are they? How strong are they? Where are they effective?
- ◆ How capable are they? What are they likely to do?

◆ The Friendly Forces

- ◆ What is our higher echelon mission and Concept of Operation? What is the mission of adjacent units?

◆ Mission

- ◆ A clear concise, statement of what the unit is to do to include who, where, when, and why of the operation.

◆ Execution

- ◆ What is the Concept of Operation? How to maneuver, how to fire, how to deal with obstacles? In Offense: what unit formations, movement techniques, routes of advance? On Defense: what battle positions to establish, weapon orientation, engagement plan, +more.

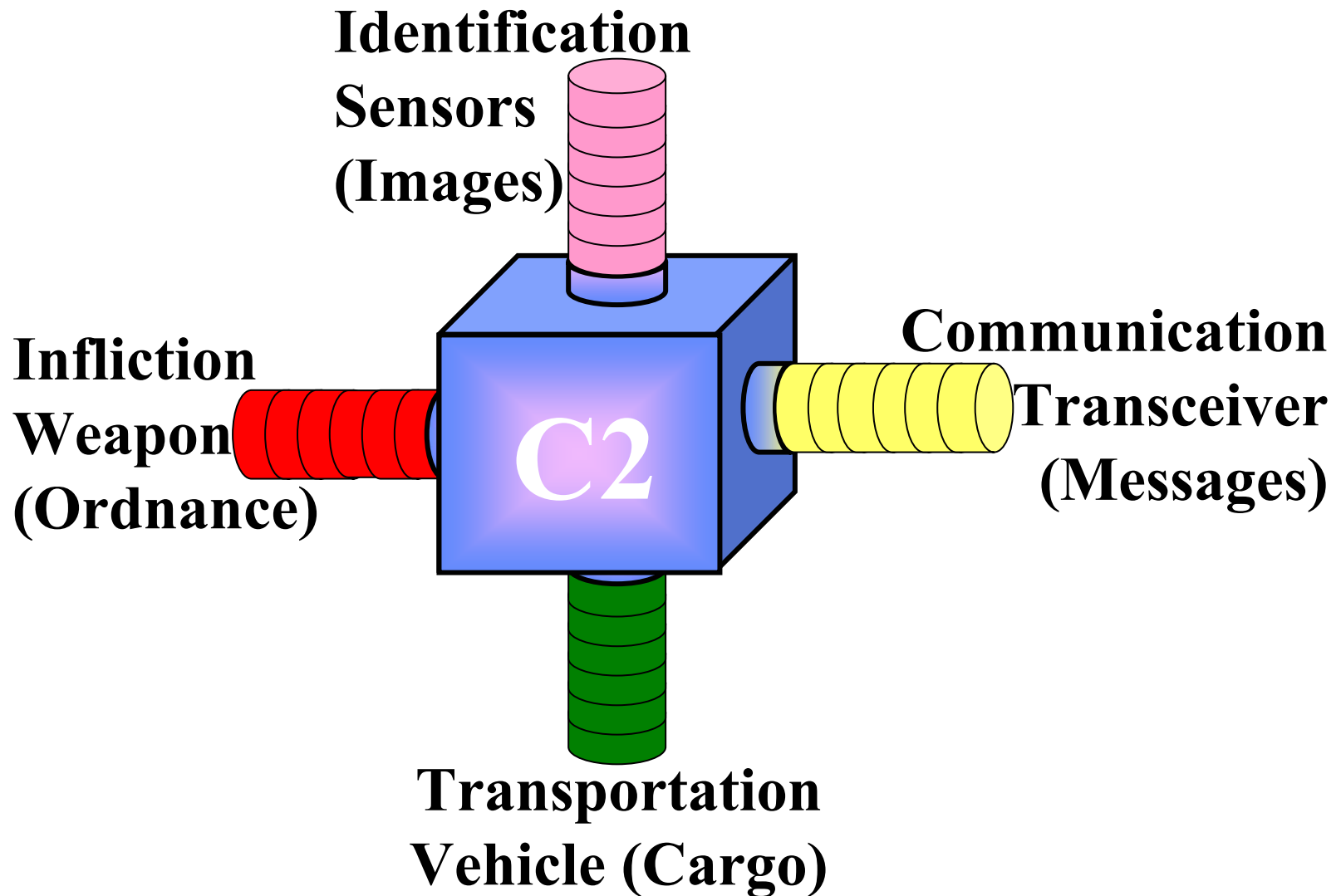
◆ Service Support

- ◆ Where is refueling, How? Where is the collection point of damaged vehicles?

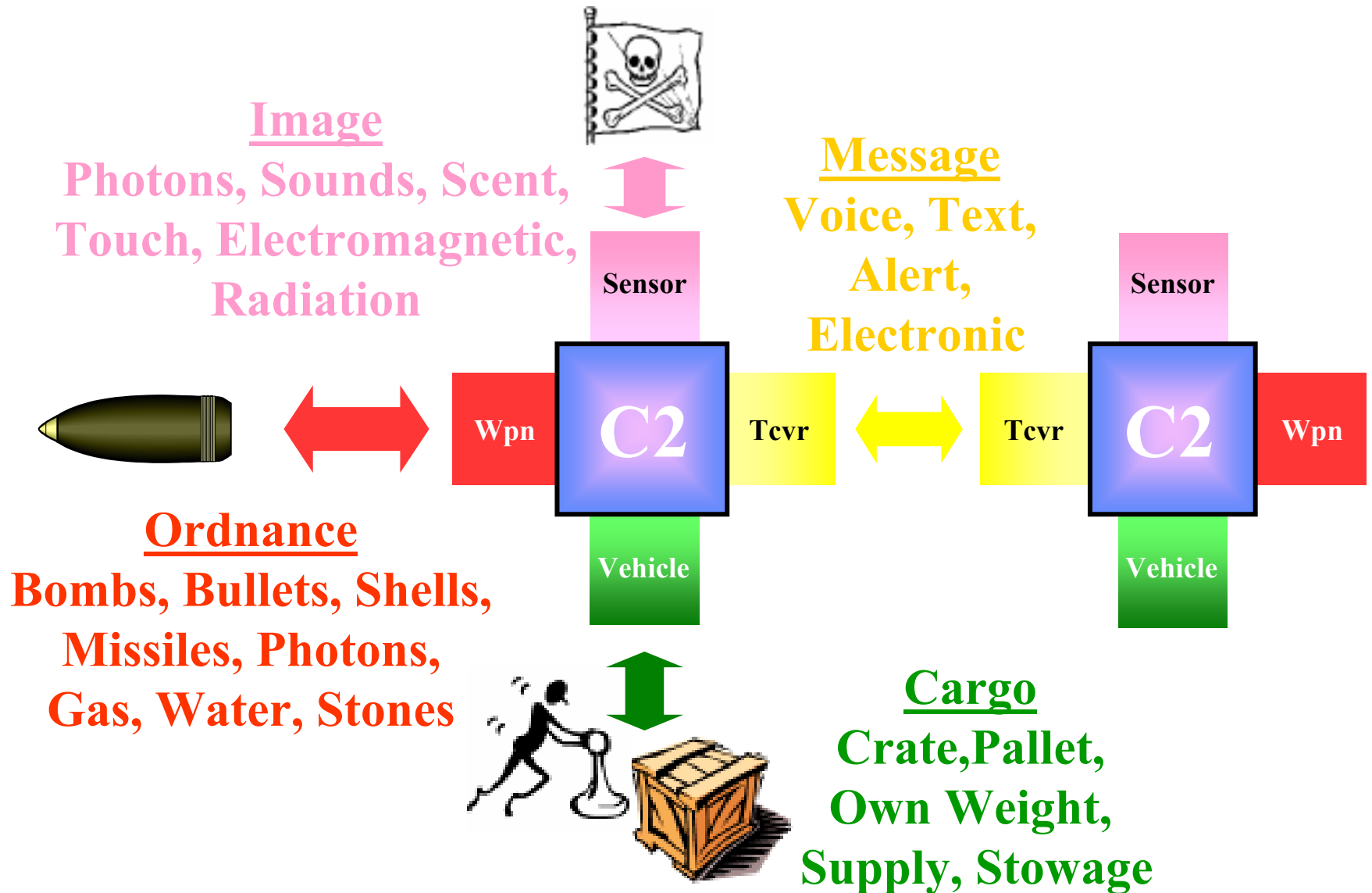
◆ Command and Signal

- ◆ How communications will be maintained?
- ◆ What is the command succession?

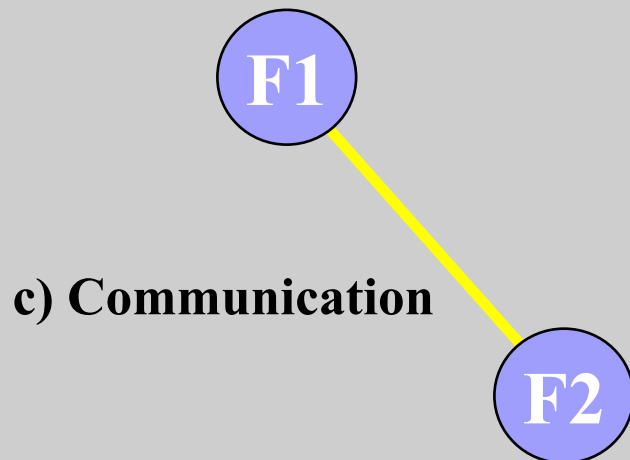
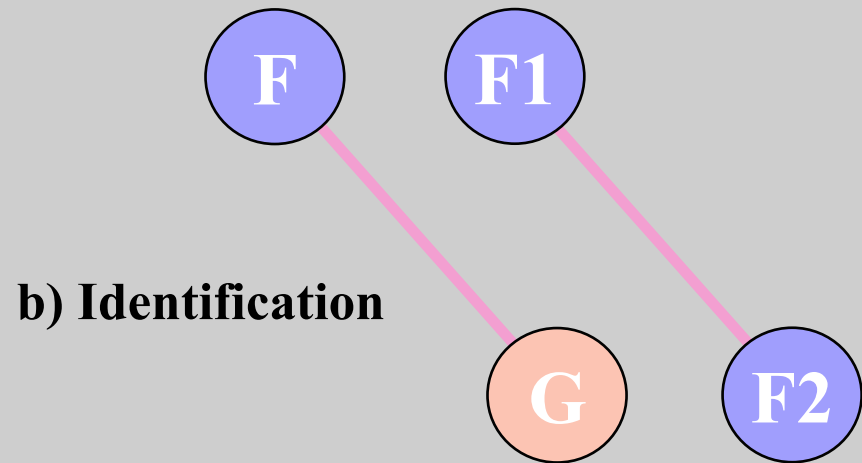
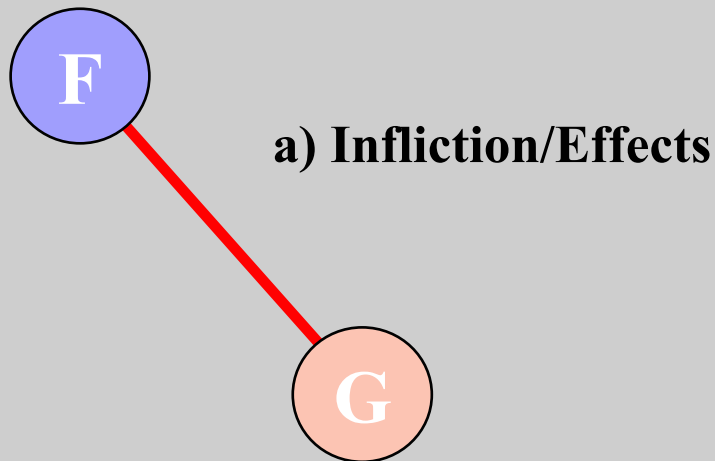
C2RM Generic Entity



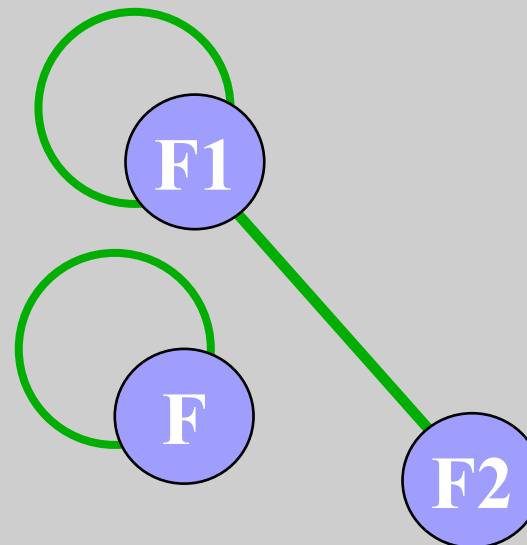
C2RM Generic Package Classes



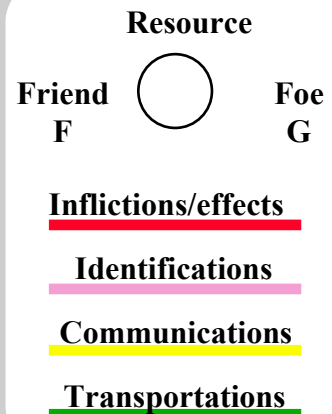
Fundamental types of Interactions



d) Transportation

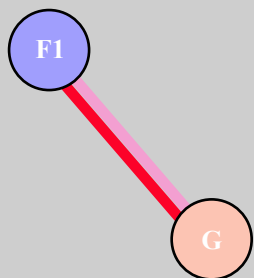


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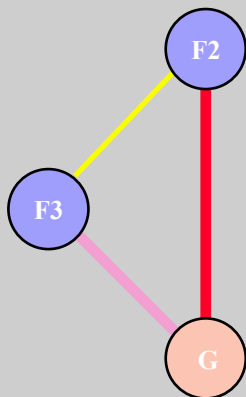


F27. Fundamental types of engagements

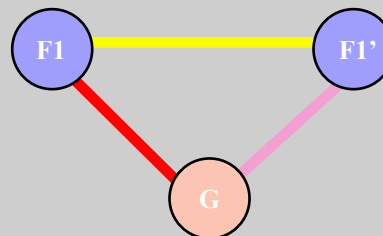
a) Direct



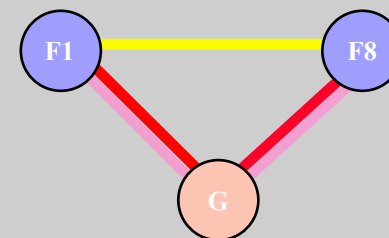
b) Direct Support/NLOS



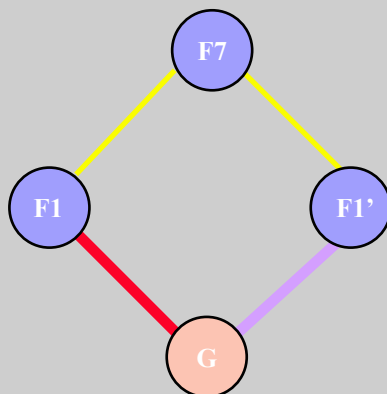
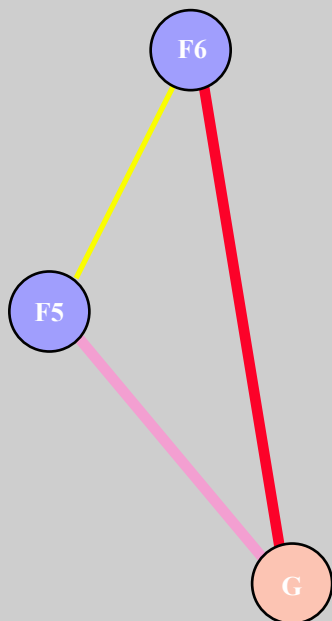
c) BLOS



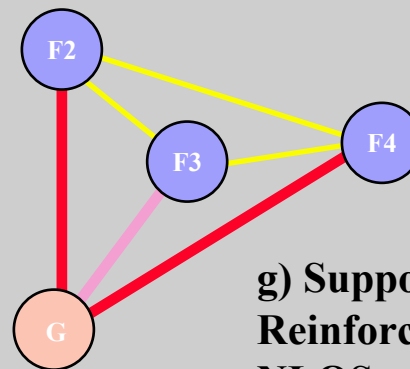
d) Coordinated



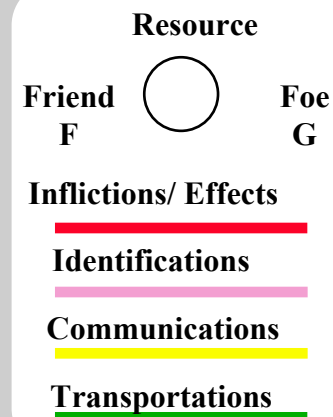
f) Managed BLOS



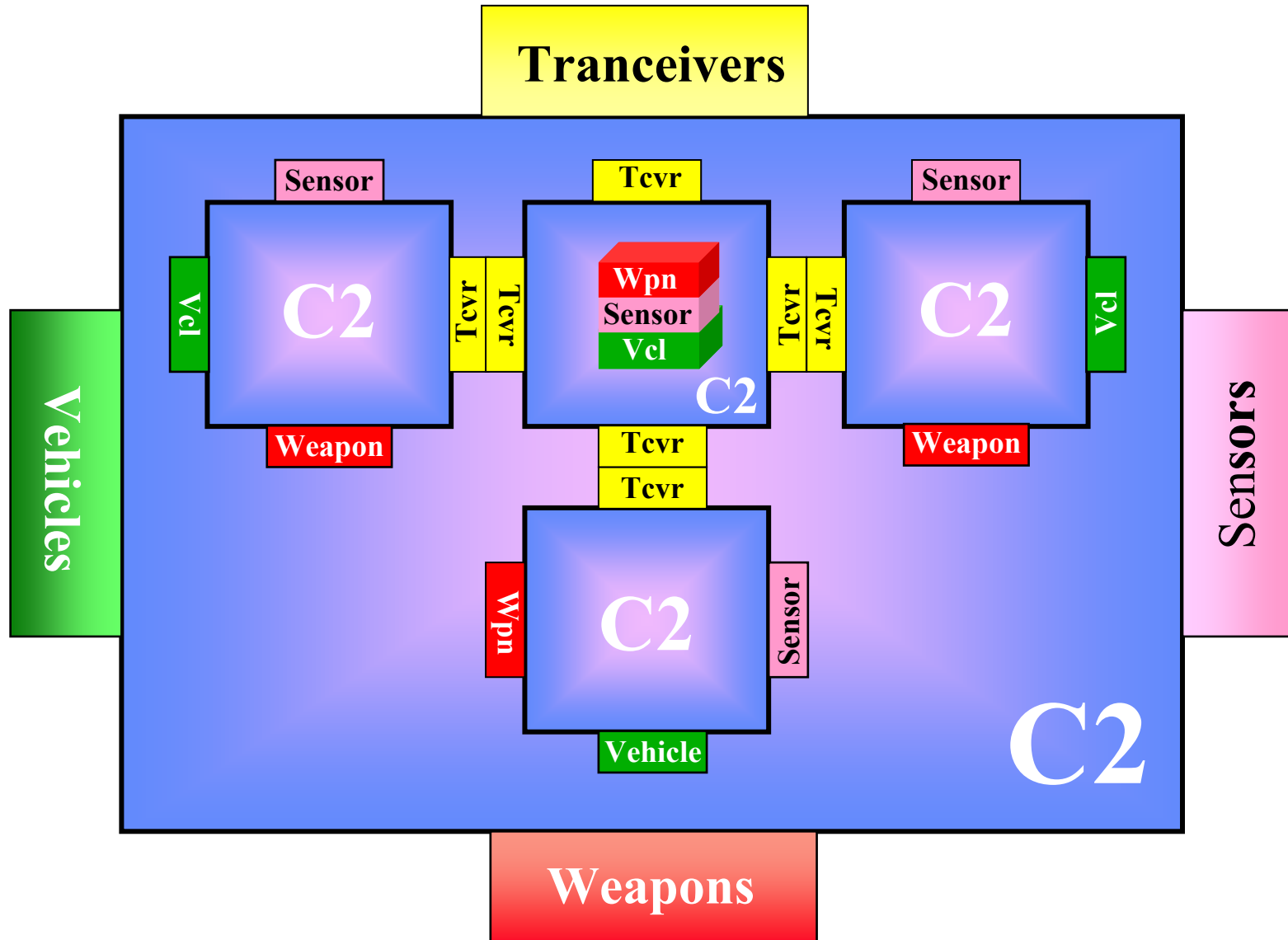
g) Support Reinforcement/NLOS



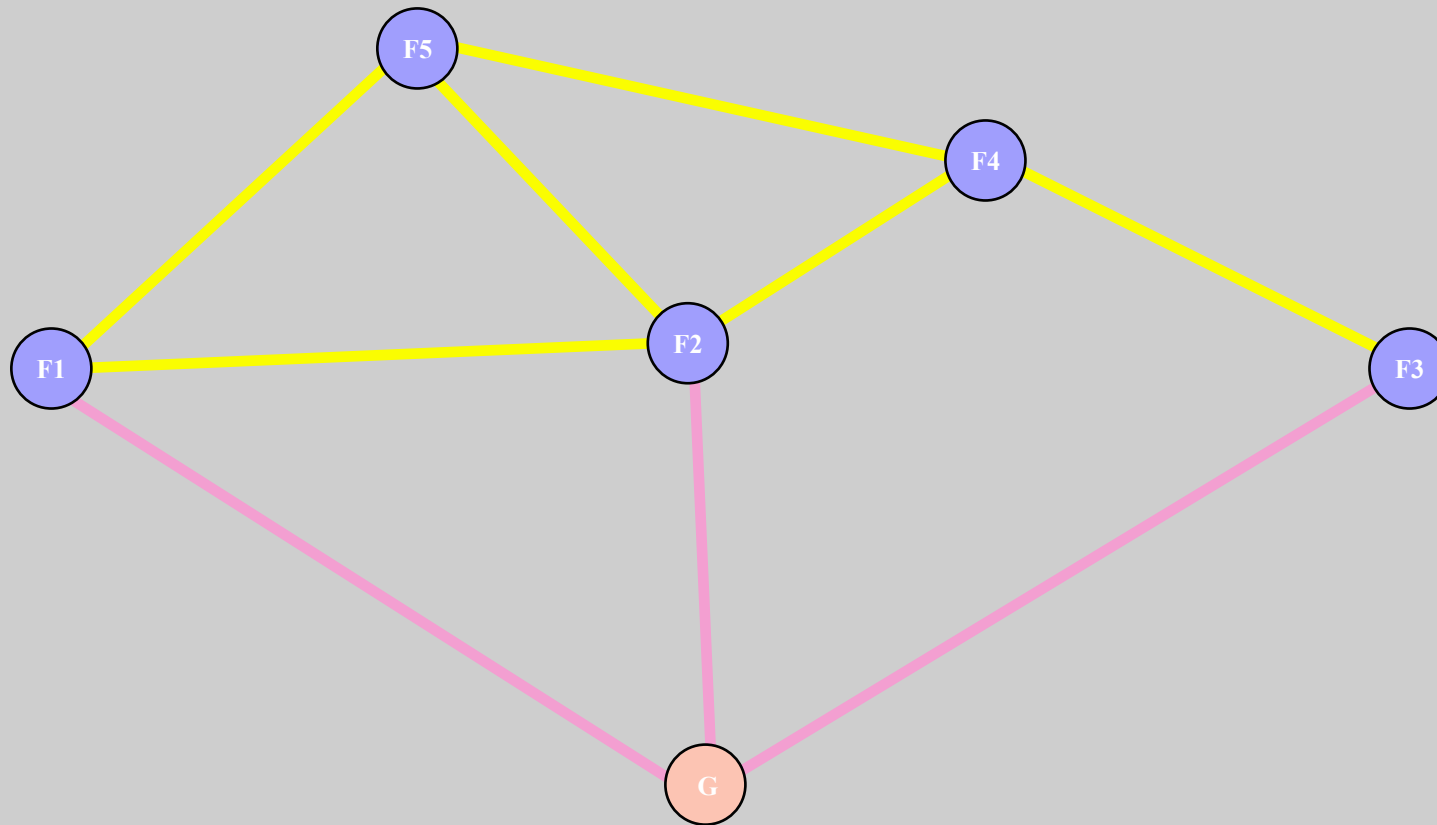
Legend:



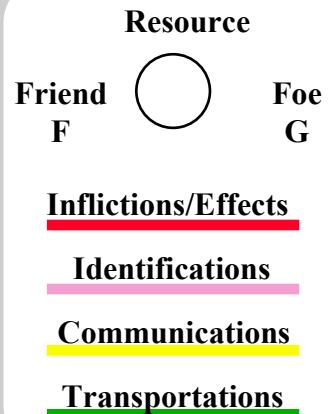
Nested/Aggregated C2RM Entities



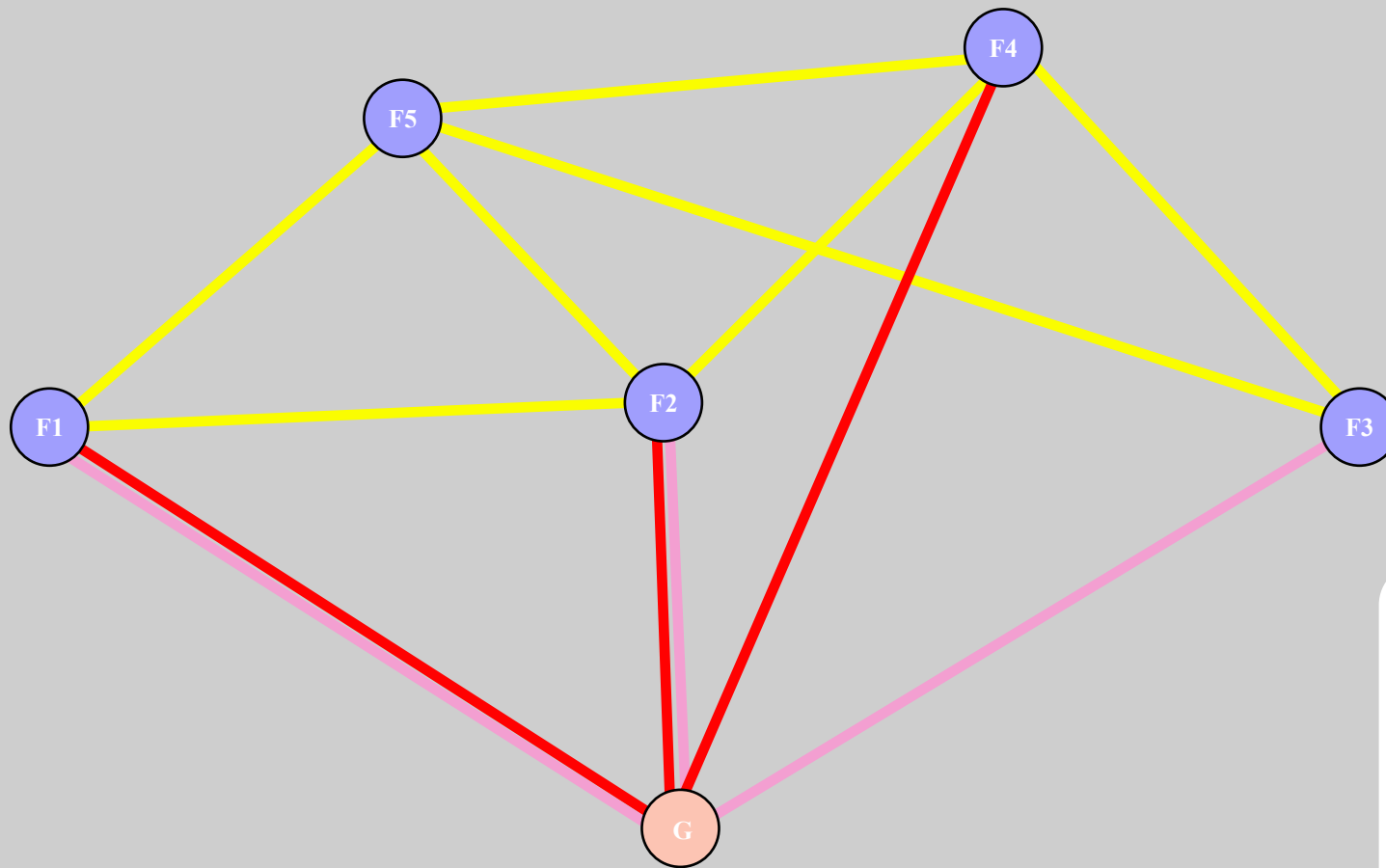
Network-Centric Sensors



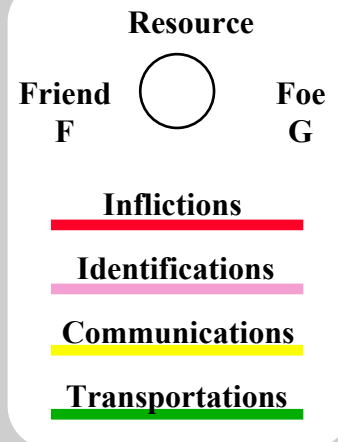
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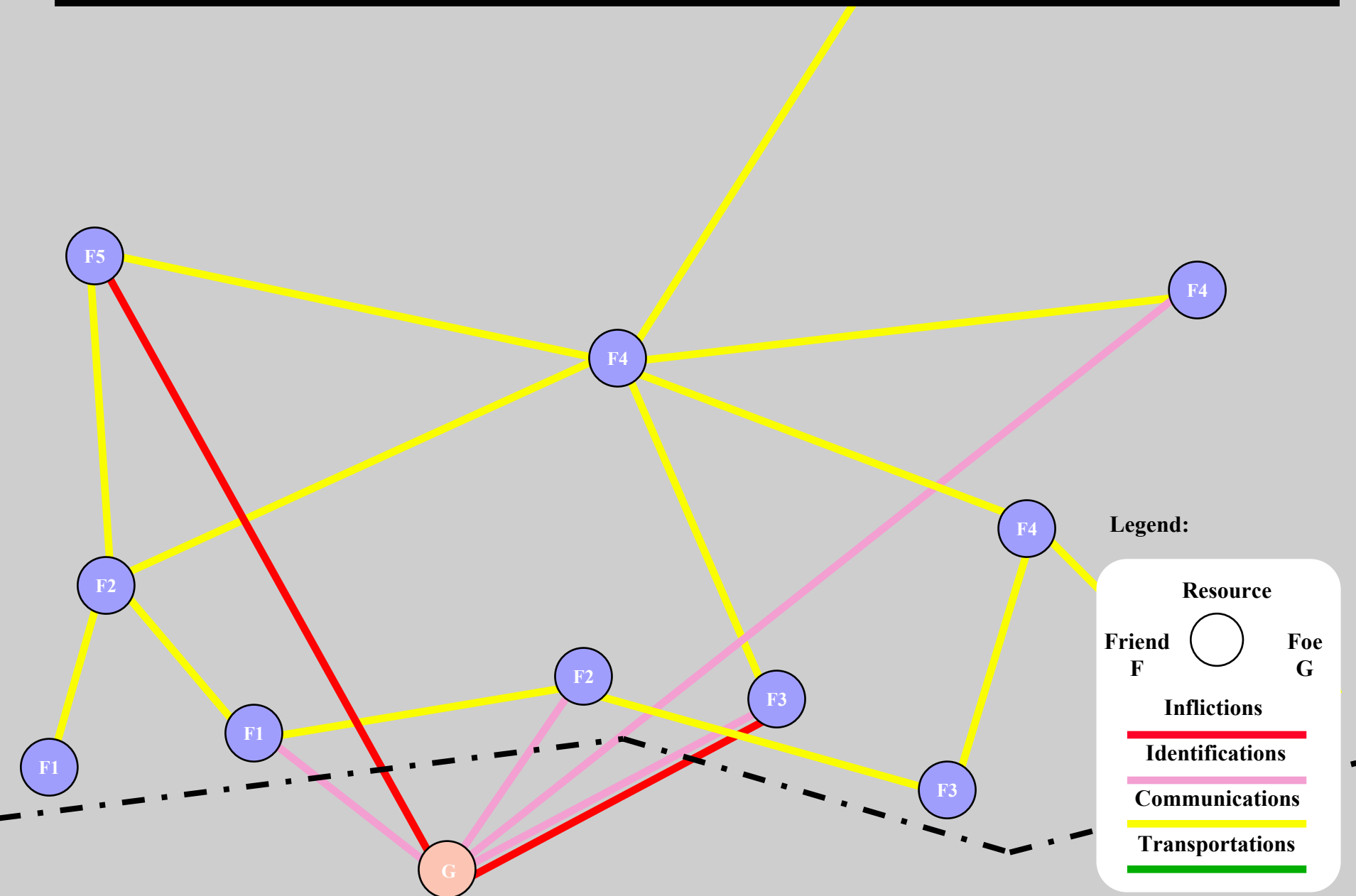
Network-Centric Fire



Legend:

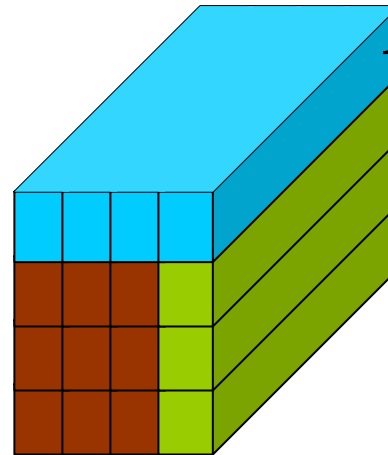


Network-Centric Border



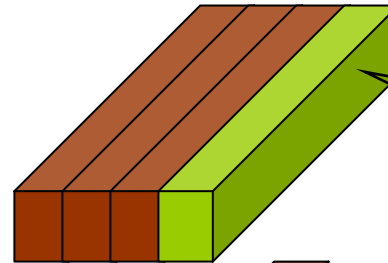
Building a Reference Force

Crew / Team



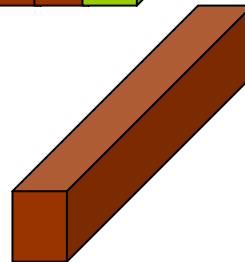
Crew / Team
C2, CS

Sec / Sqd

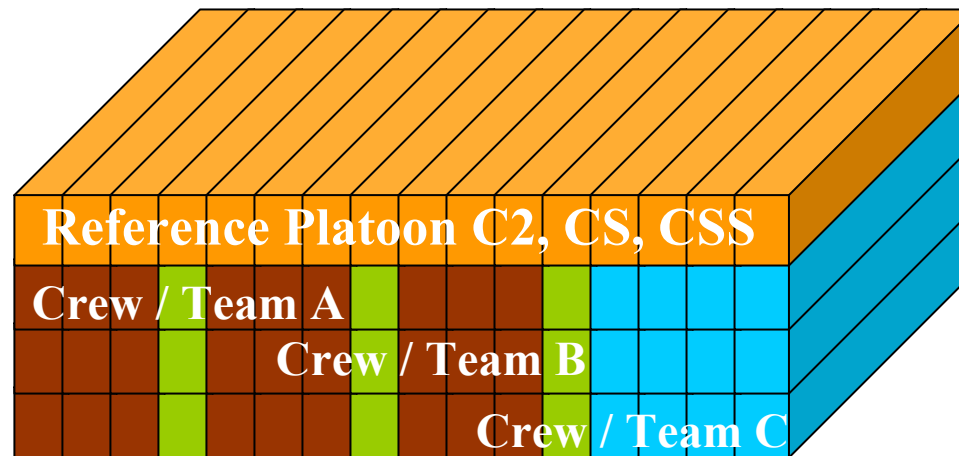


Sec / Sqd
C2 / CS

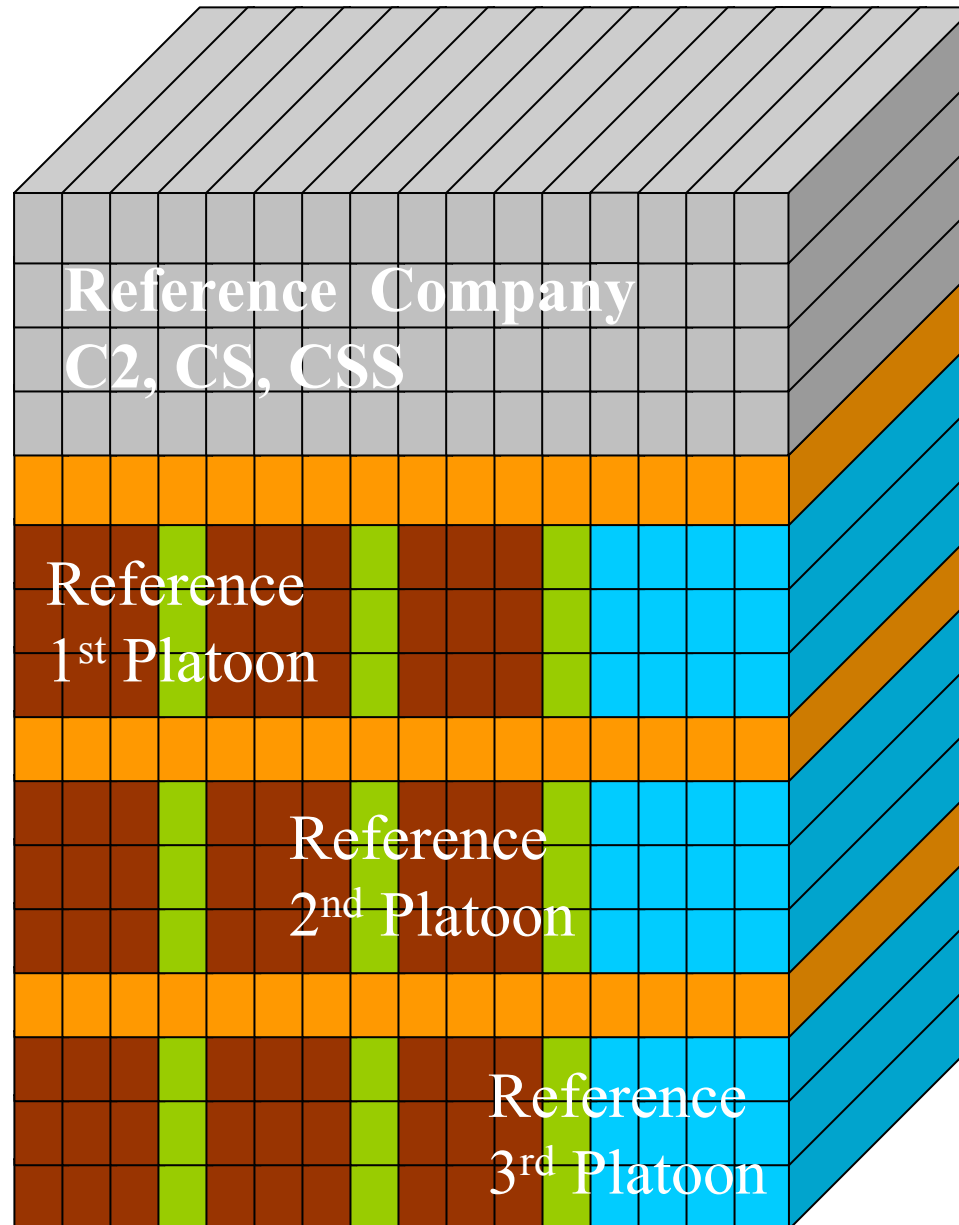
Individual



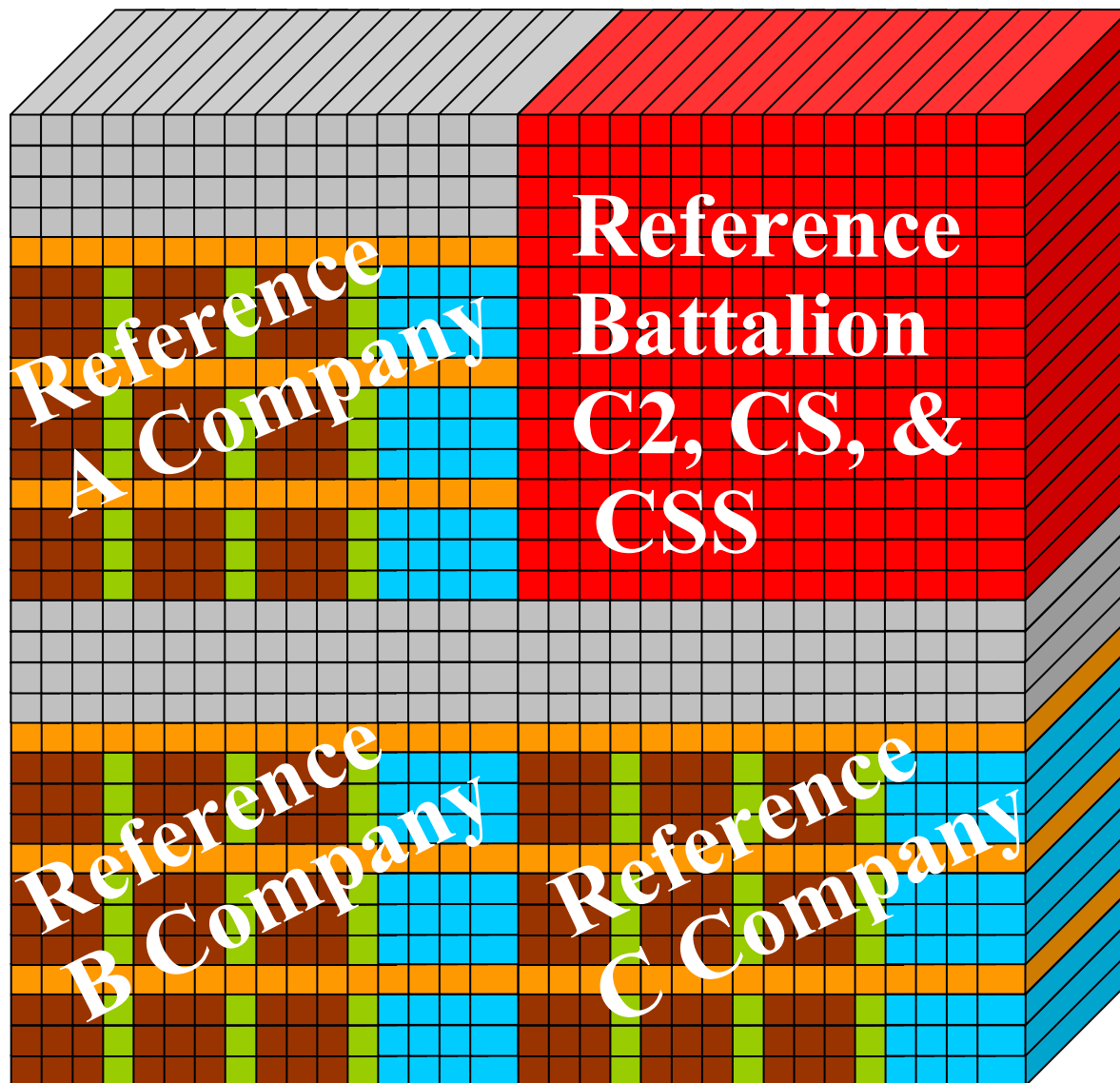
A Reference Platoon



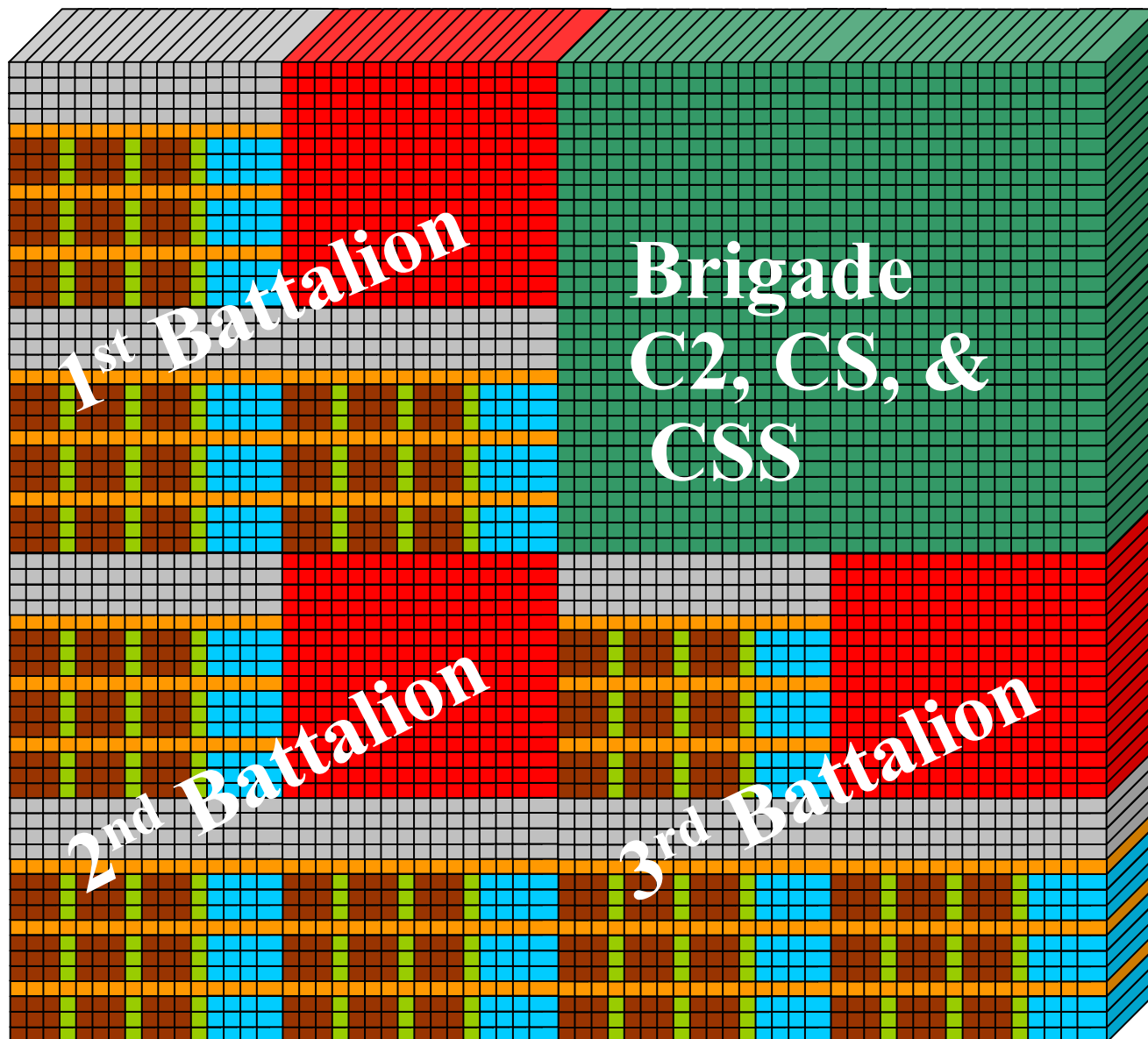
A Reference Company



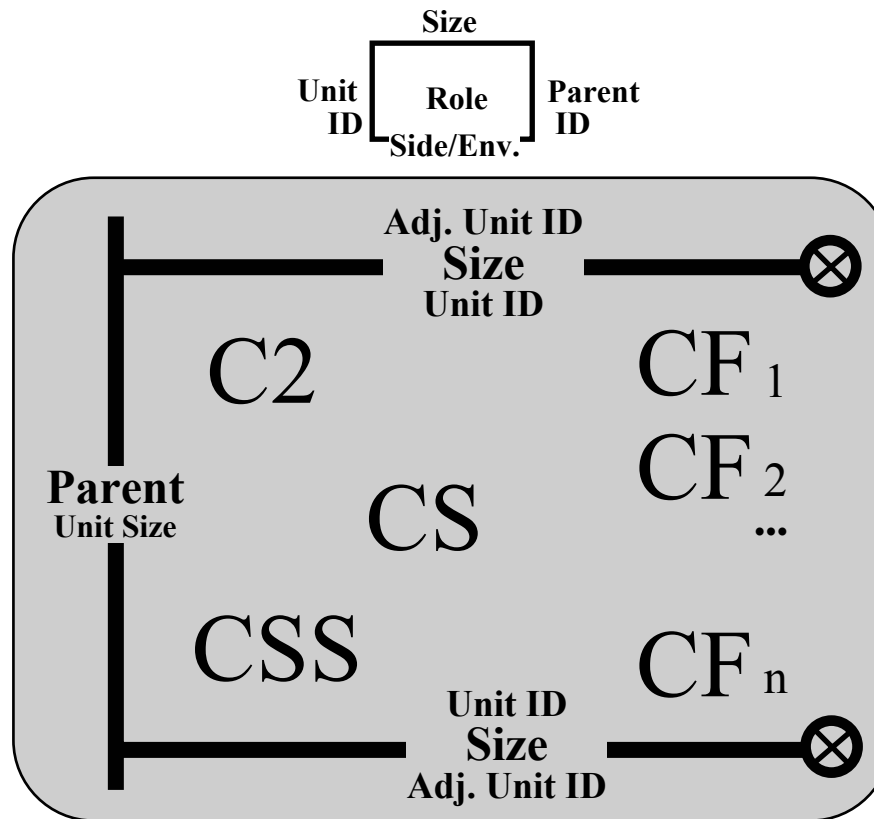
A Reference Battalion



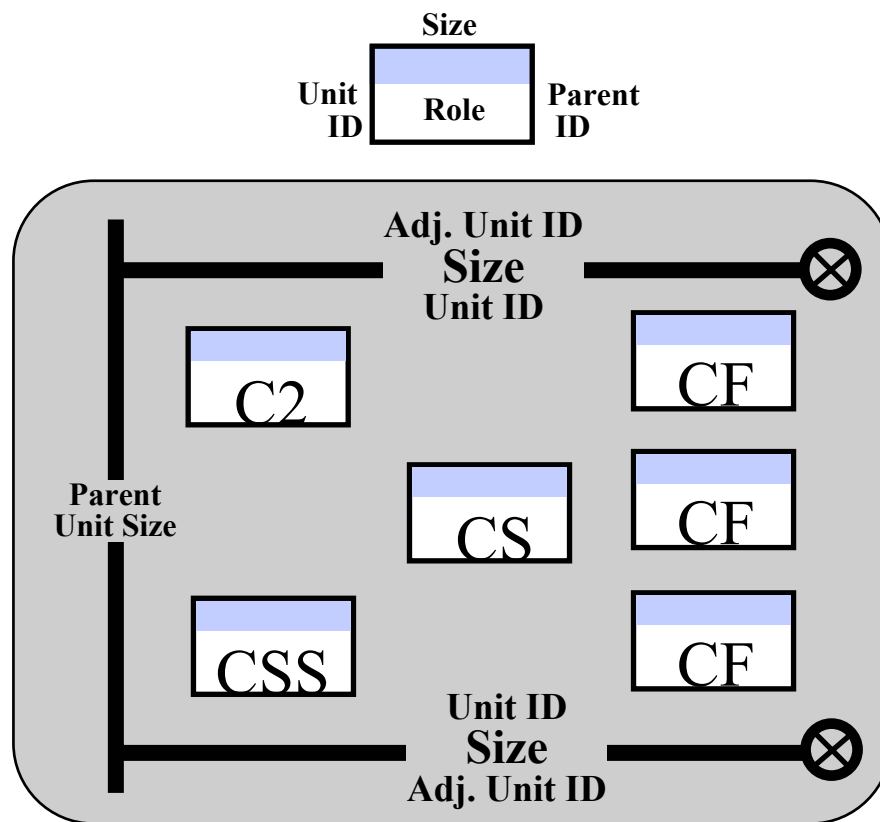
A Reference Brigade



Generic Unit Representation

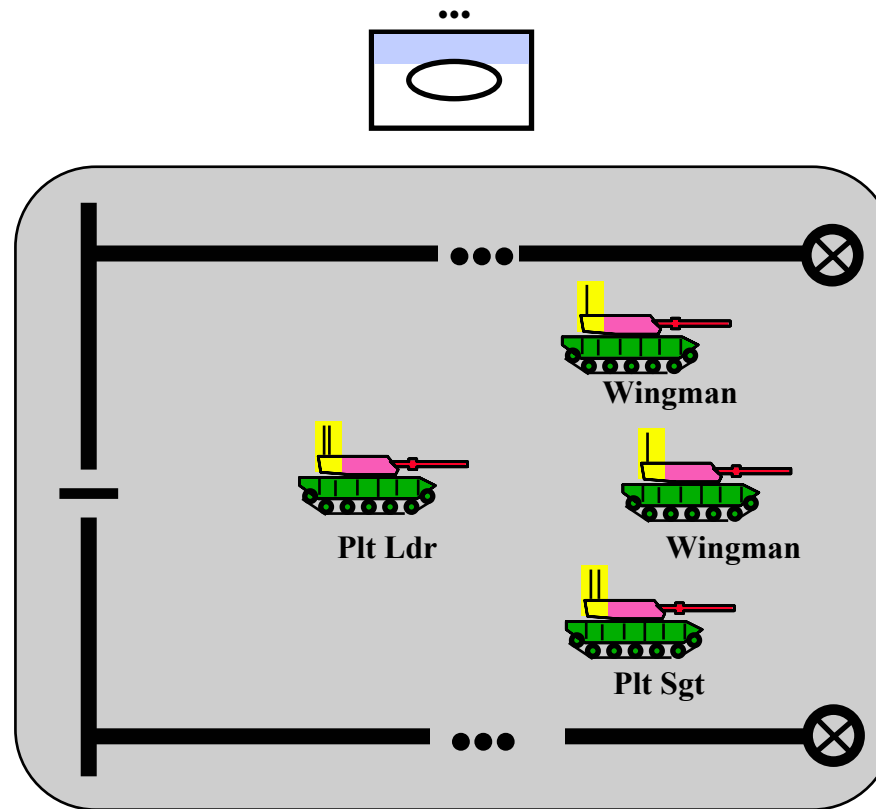


Ground Unit Representation



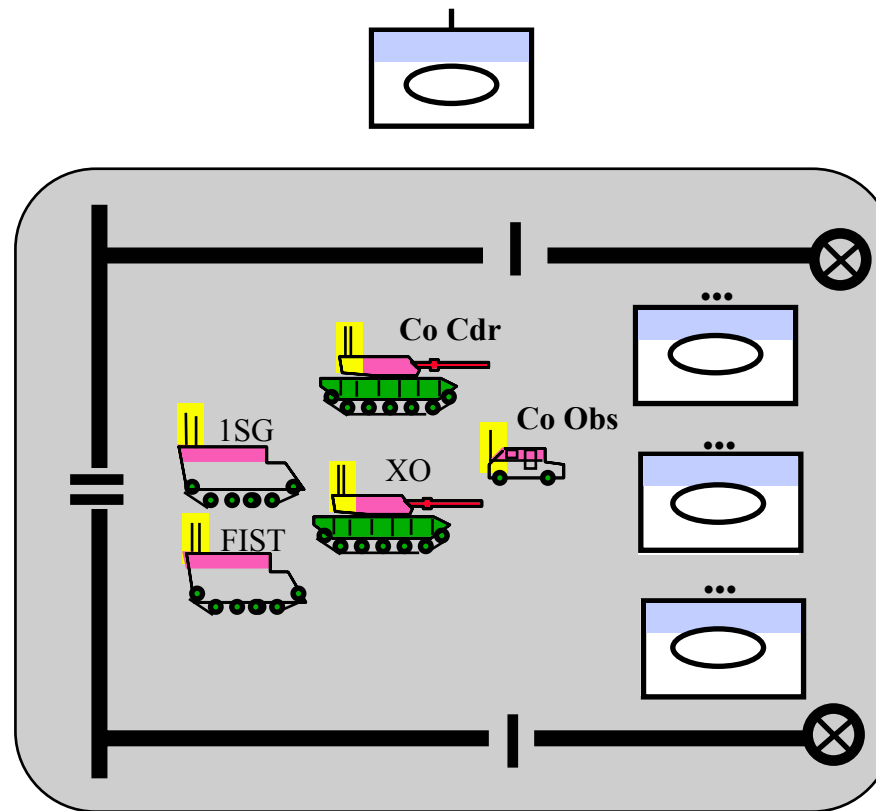
Armor Unit Representation

Platoon Example



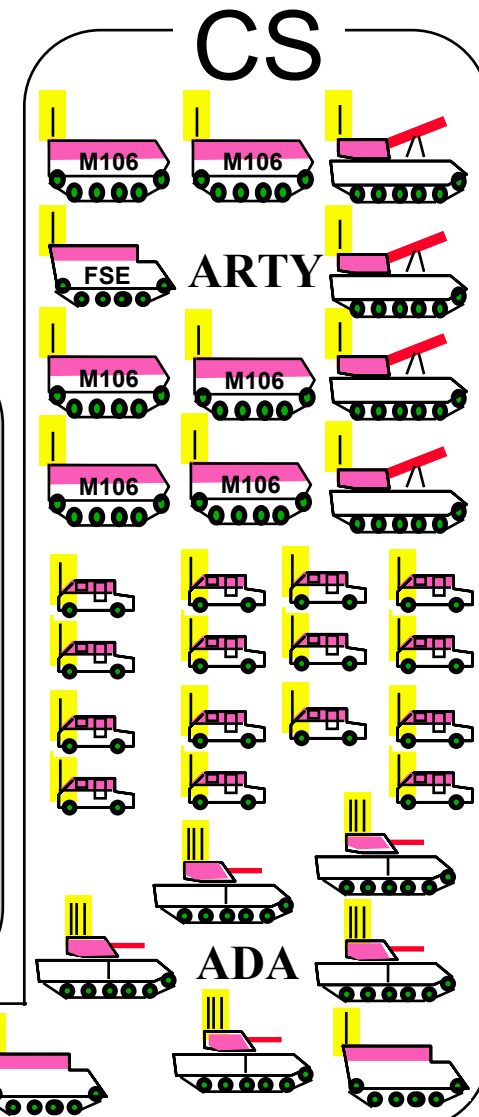
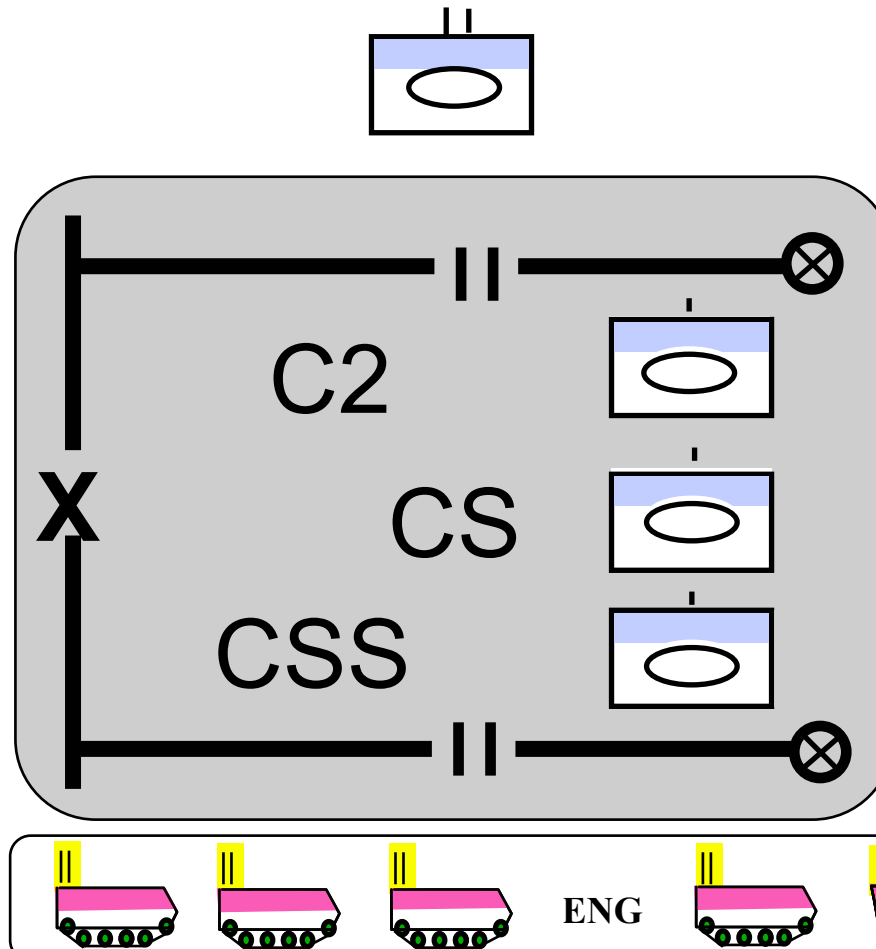
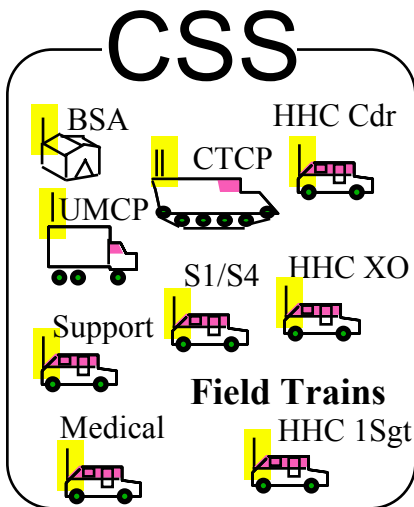
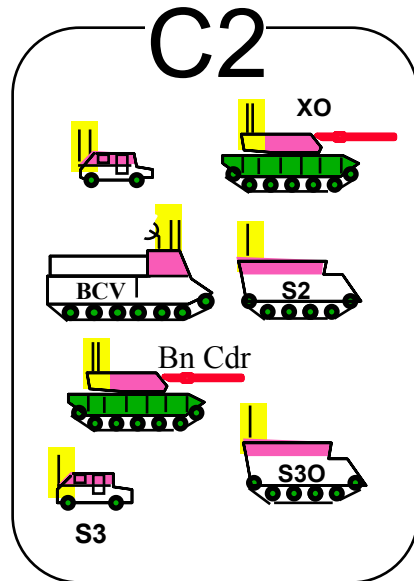
Armor Unit Representation

Company Example



Armor Unit Representation

Battalion Example



C2 Systems are like Onions

Onions have layers

Regardless of whether one likes them or not

C2 Systems also have layers



The world
according to
Shrek

Layers, therefore, are essential to describing onions
Similarly, Layered architectures are critical in
representing C2 Systems

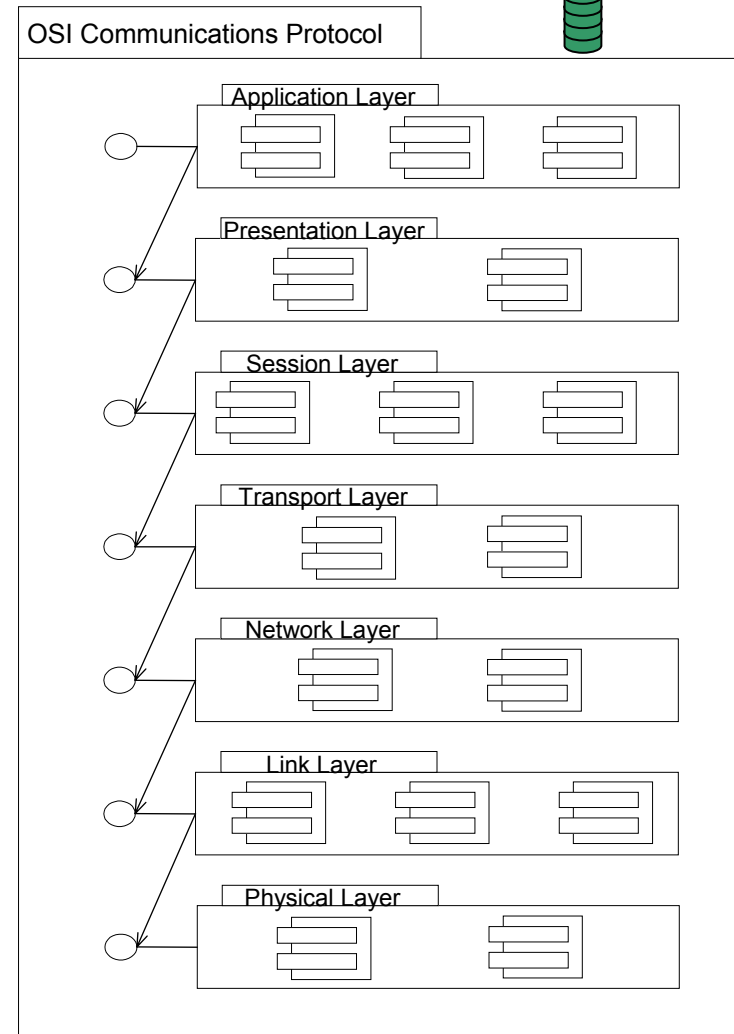
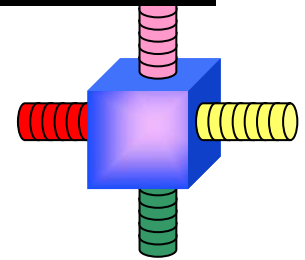
Every Port Consists of 7 Logical Layers

(According / Analogous to the OSI Communication Layer Model)

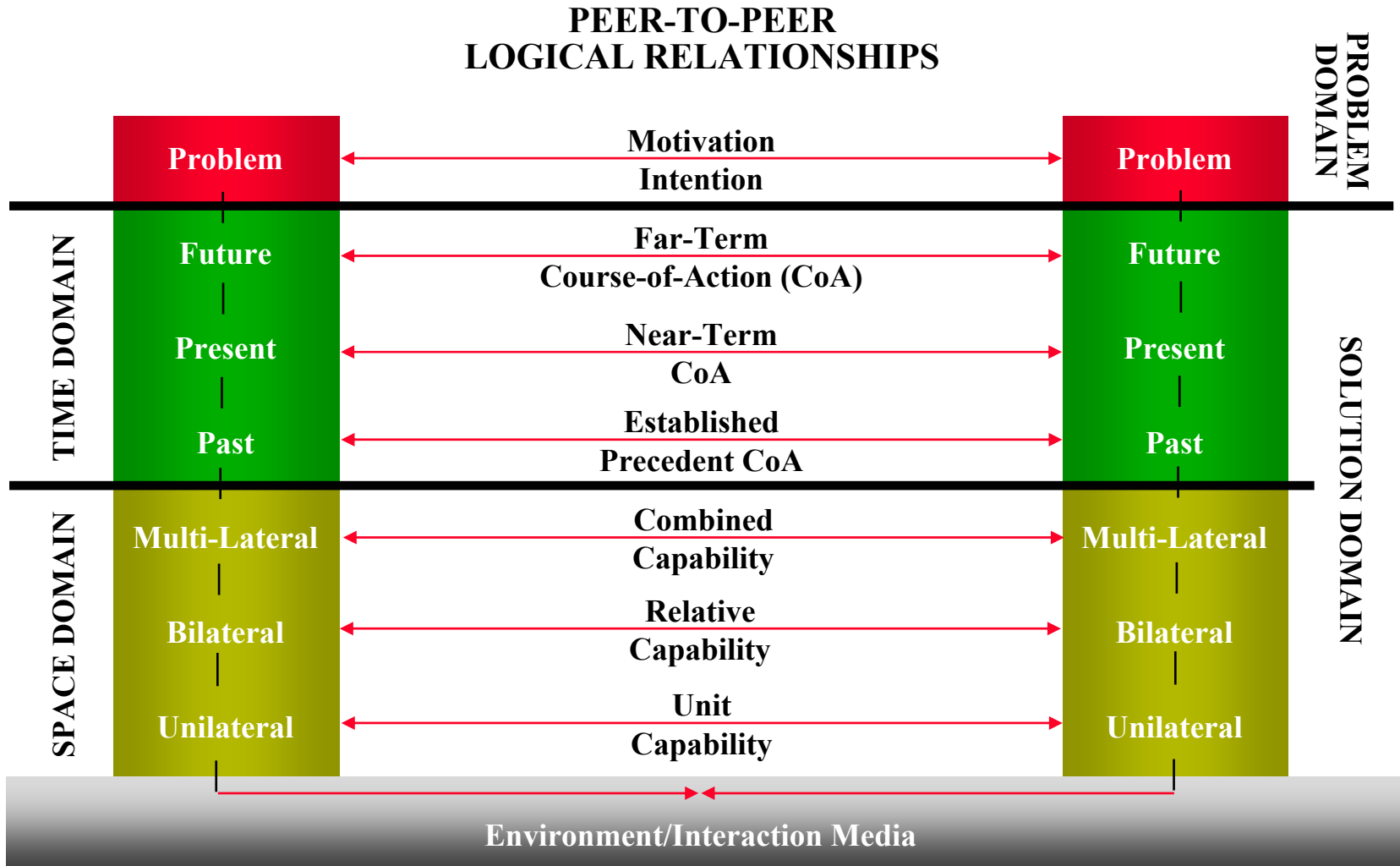
Example

The Communication Port includes the following layers :

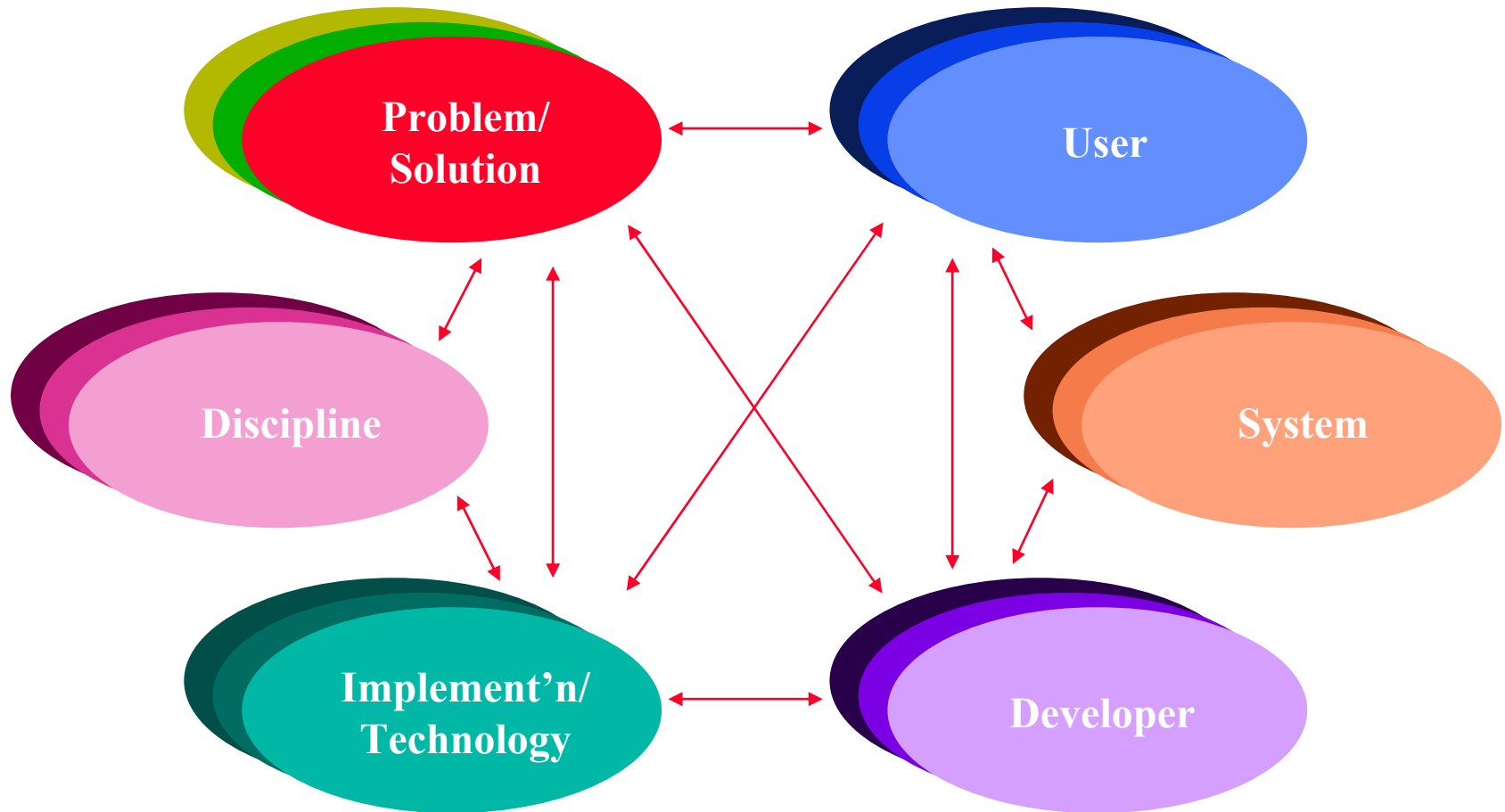
7. **Application Layer** – The GOAL of the C2 process enabled by the port.
6. **Presentation Layer** – translates formats between the port and the application.
5. **Session** – responsible for a complete sequence / dialog of actions necessary to complete a set of transactions.
4. **Transport** – a middle and supervising layer to provide transparency of the networking between any two port types/users.
3. **Network** – multi-connection between more than two assets of the same port type.
2. **Link** – single connection between two assets of the same port type.
1. **Physical** – the port's electrical and physical interface to the environment.



F6. Layering the Problem/Solution domain



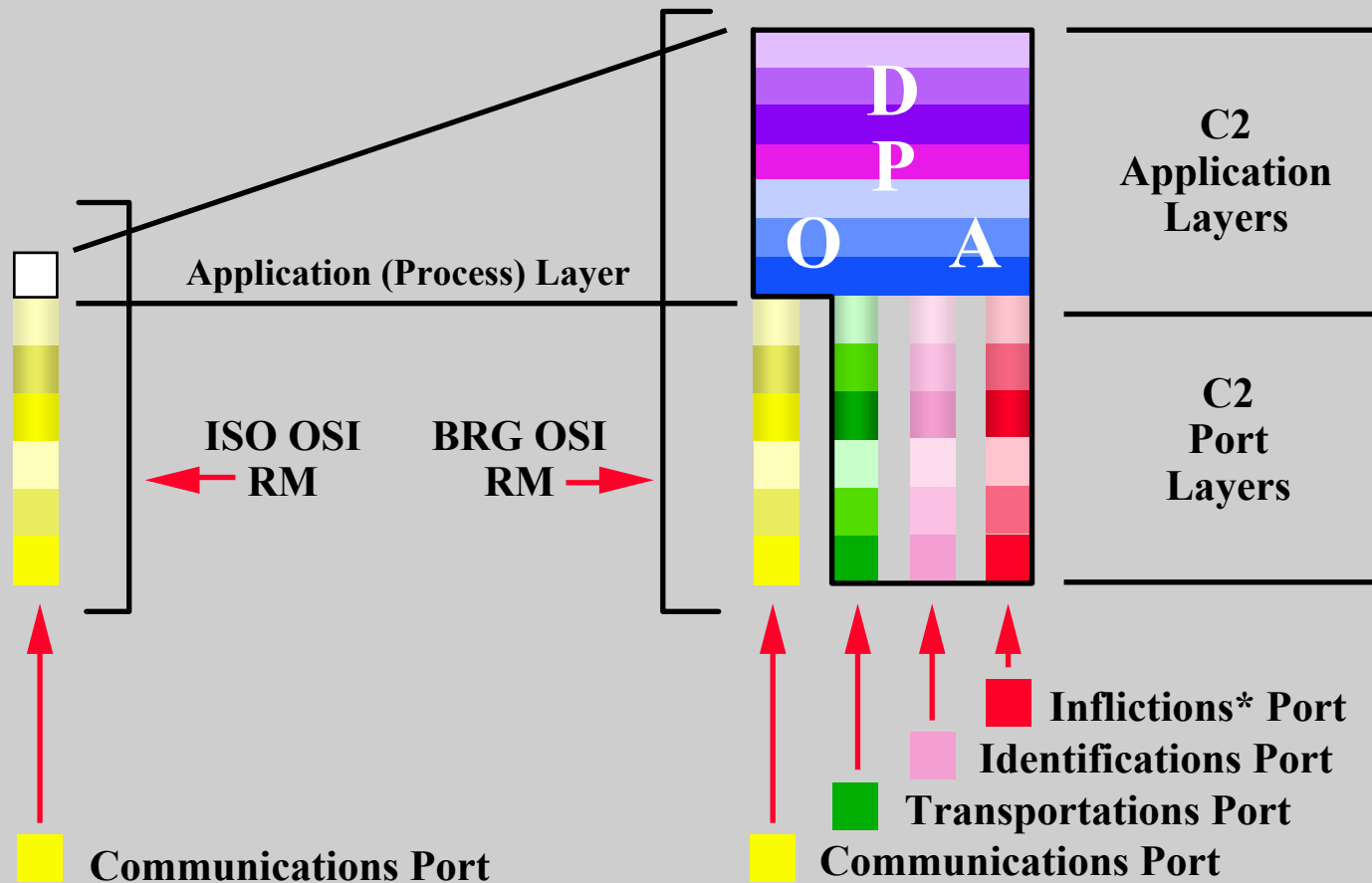
F5. Domains for developing C2 objects



Extending the ISO OSI RM to C2

An ISO OSI RM System

A C2RM Unit, Resource, Asset



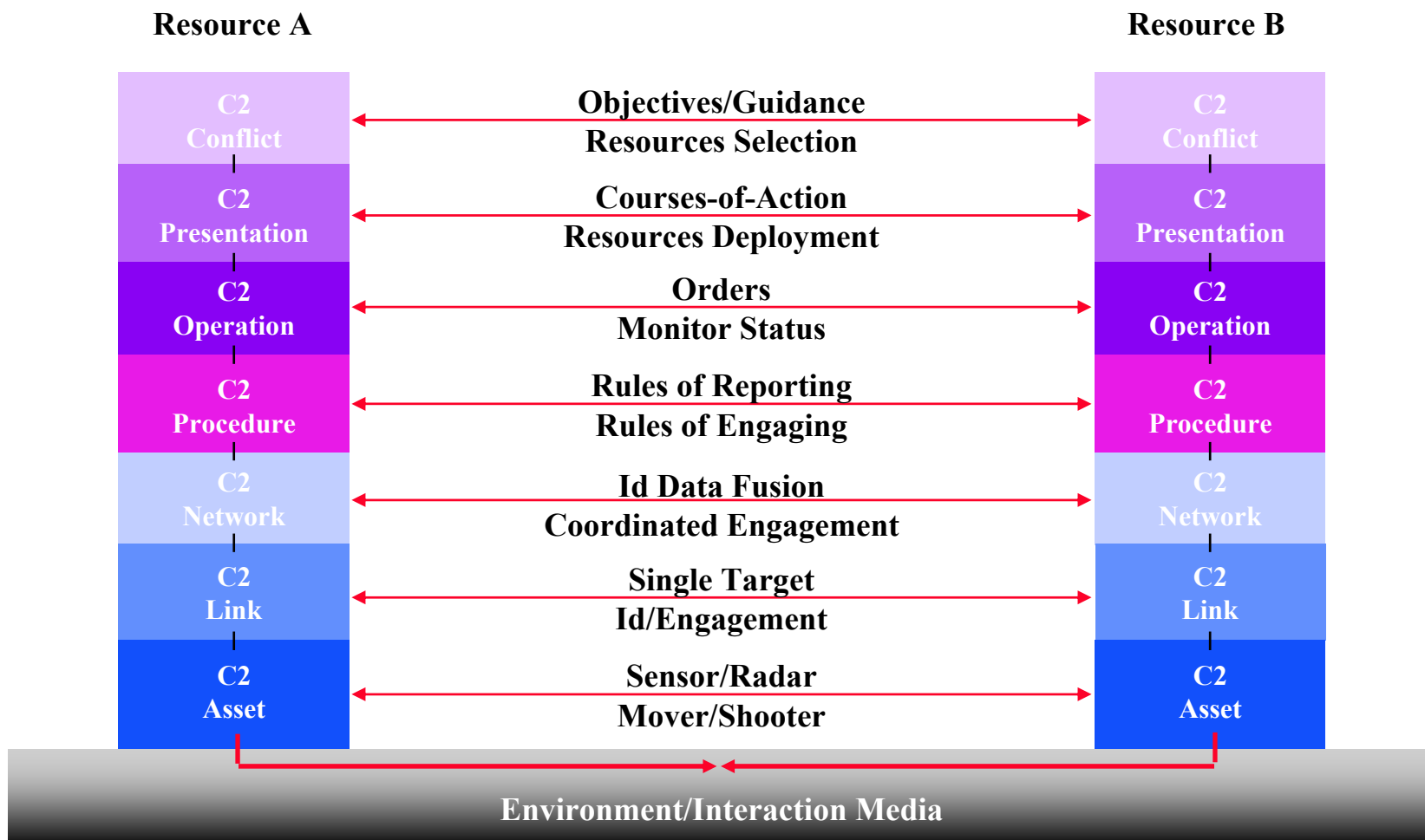
*Inflictions = Negative Effects / Impacts (lethal / non-lethal)

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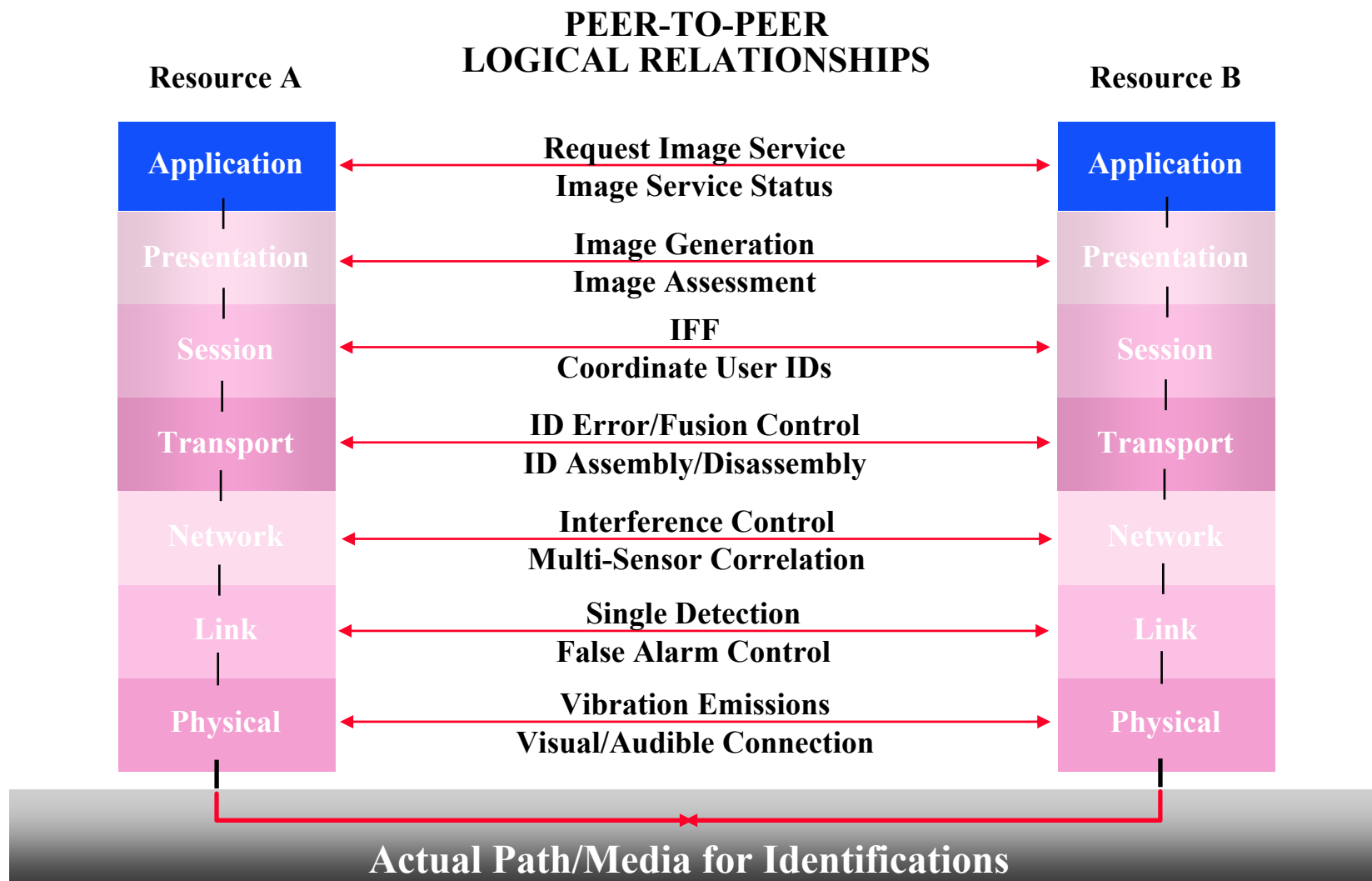
Israel Mark, US Army CERDEC

C2 applications Layers

PEER-TO-PEER LOGICAL RELATIONSHIPS



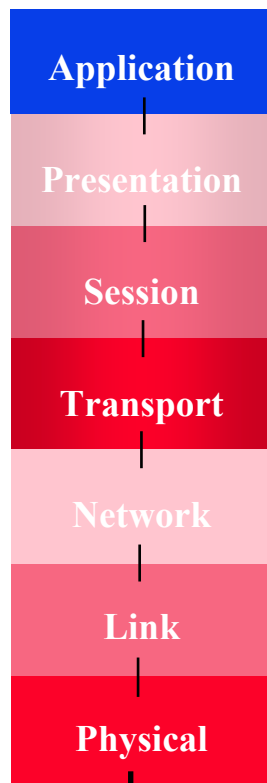
Identifications Layers



Inflictions Layers

PEER-TO-PEER LOGICAL RELATIONSHIPS

Resource A



Application

Presentation

Session

Transport

Network

Link

Physical

Request Negative Effect / Impact Service
Impact Service Status

Feasible Negative Effect / Impact
Negative Effect / Impact Assessment

Delivery Readiness
Synchronize Deliveries

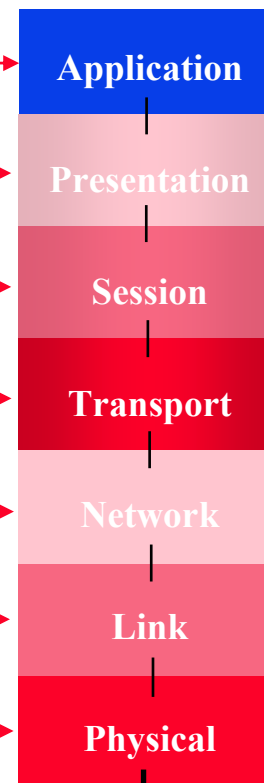
Delivery Flow Control
Delivery Logistics

Positioning Control
Delivery Coordination

Delivery Range
Delivery Error Control

Armament Load
Armament Range

Resource A



Application

Presentation

Session

Transport

Network

Link

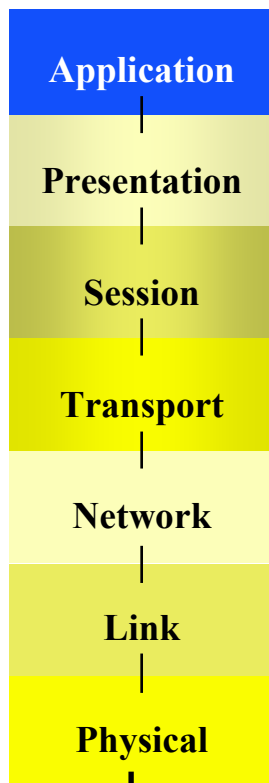
Physical

Actual Path/Media for Inflictions

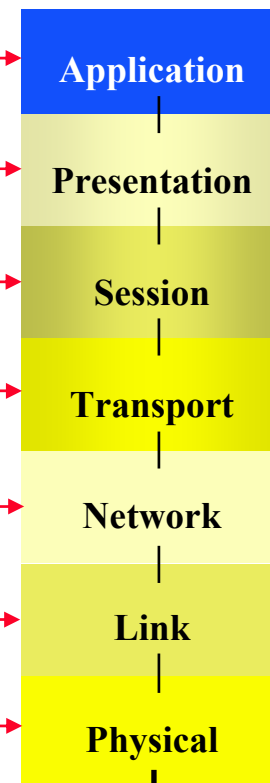
Communications Layers

PEER-TO-PEER LOGICAL RELATIONSHIPS

Resource A



Resource B



Request Msg. Service
Msg. Service Status

User Msg. Encoding
User Msg. Decoding

ETE Connection
Synchronize User Tasks

ETE Error/Flow Control
MSG Assembly/Disassembly

Route/Congestion Control
Internetwork/Packageize

Single Hop Connection
Single Hop Error Control

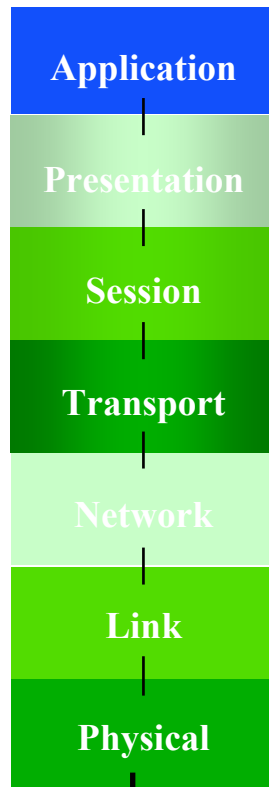
Electronic/Photonic Signals
Cable/Wire Connection

Actual Path/Media for Communications

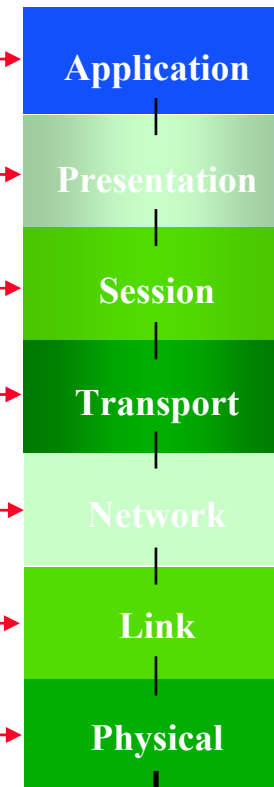
Transportations Layers

PEER-TO-PEER LOGICAL RELATIONSHIPS

Resource A



Resource B



Request Cargo Service
Cargo Service Status

Cargo Supply
Cargo Demand

Logistic Support
Synchronize User Tasks

Logistic Flow Control
Cargo Assembly/Disassembly

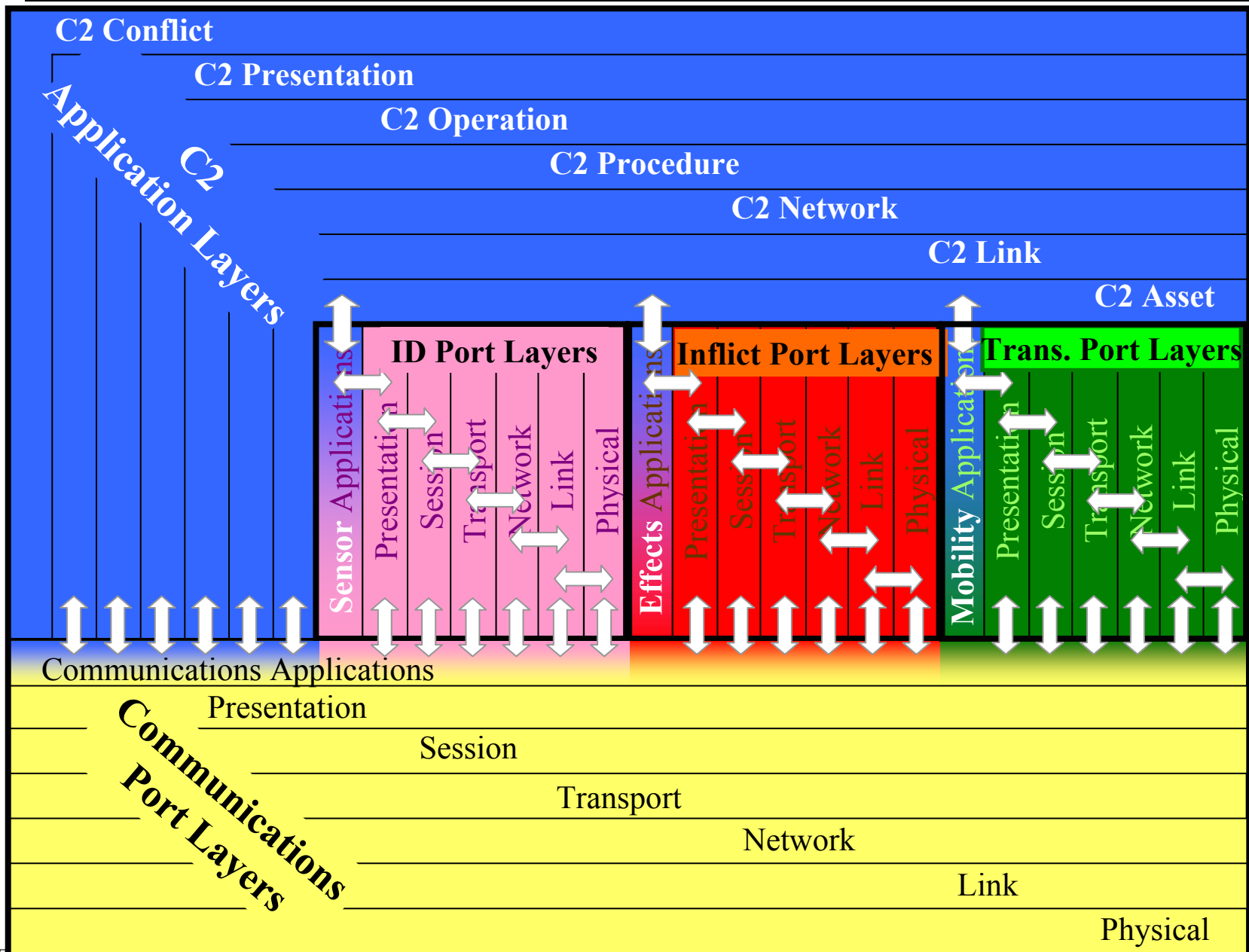
Route/Congestion Control
Multipath Navigation

Single Road Connection
Single Road Navigation

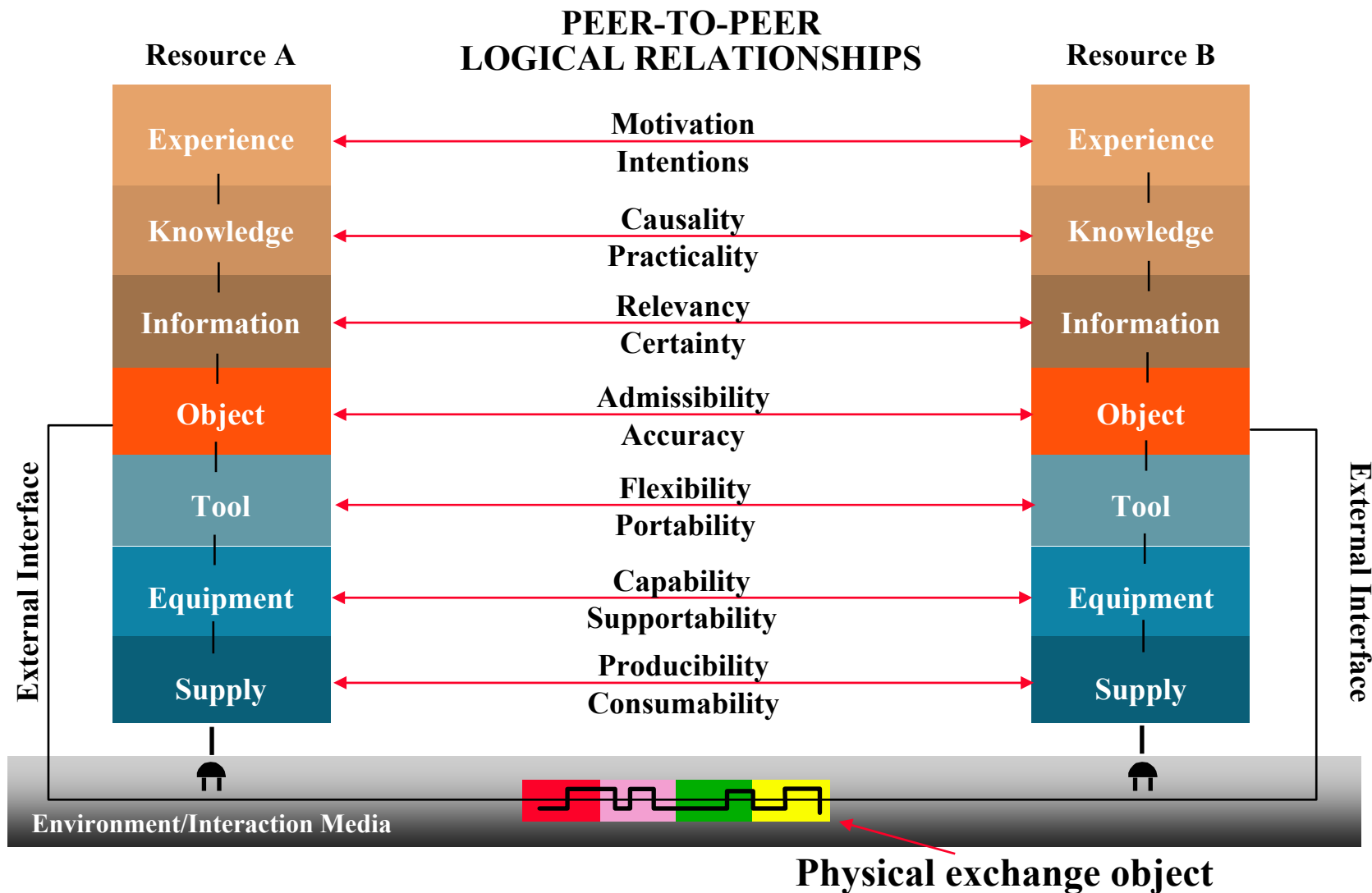
Mechanical Force
Wheels/Tracks/Wings

Actual Path/Media for Transportations

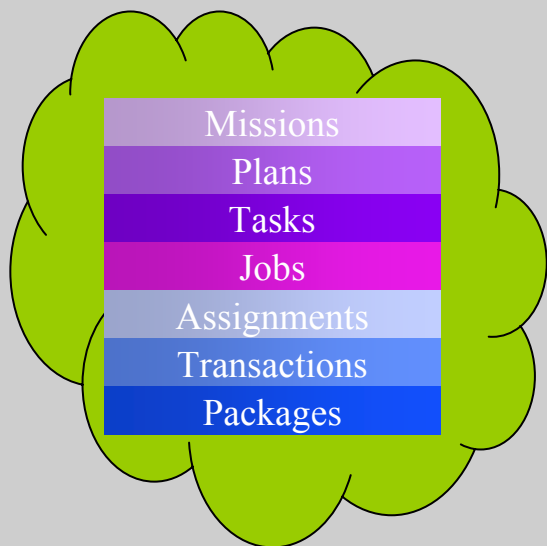
C2 and Port Layers Integration



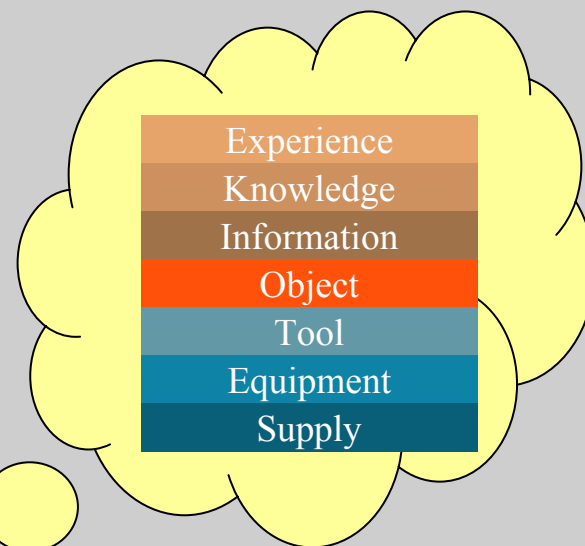
F33. Technology base layers



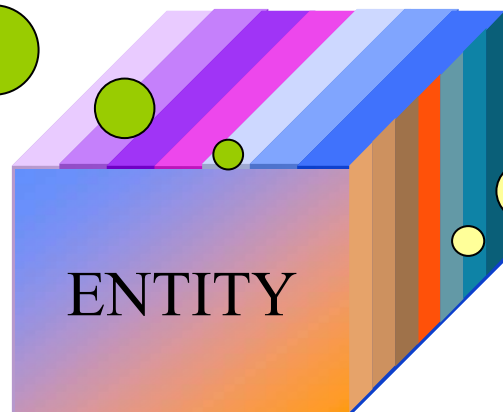
Entity Domains



**Problem-Solution
Domain {Operational &
Organizational}**

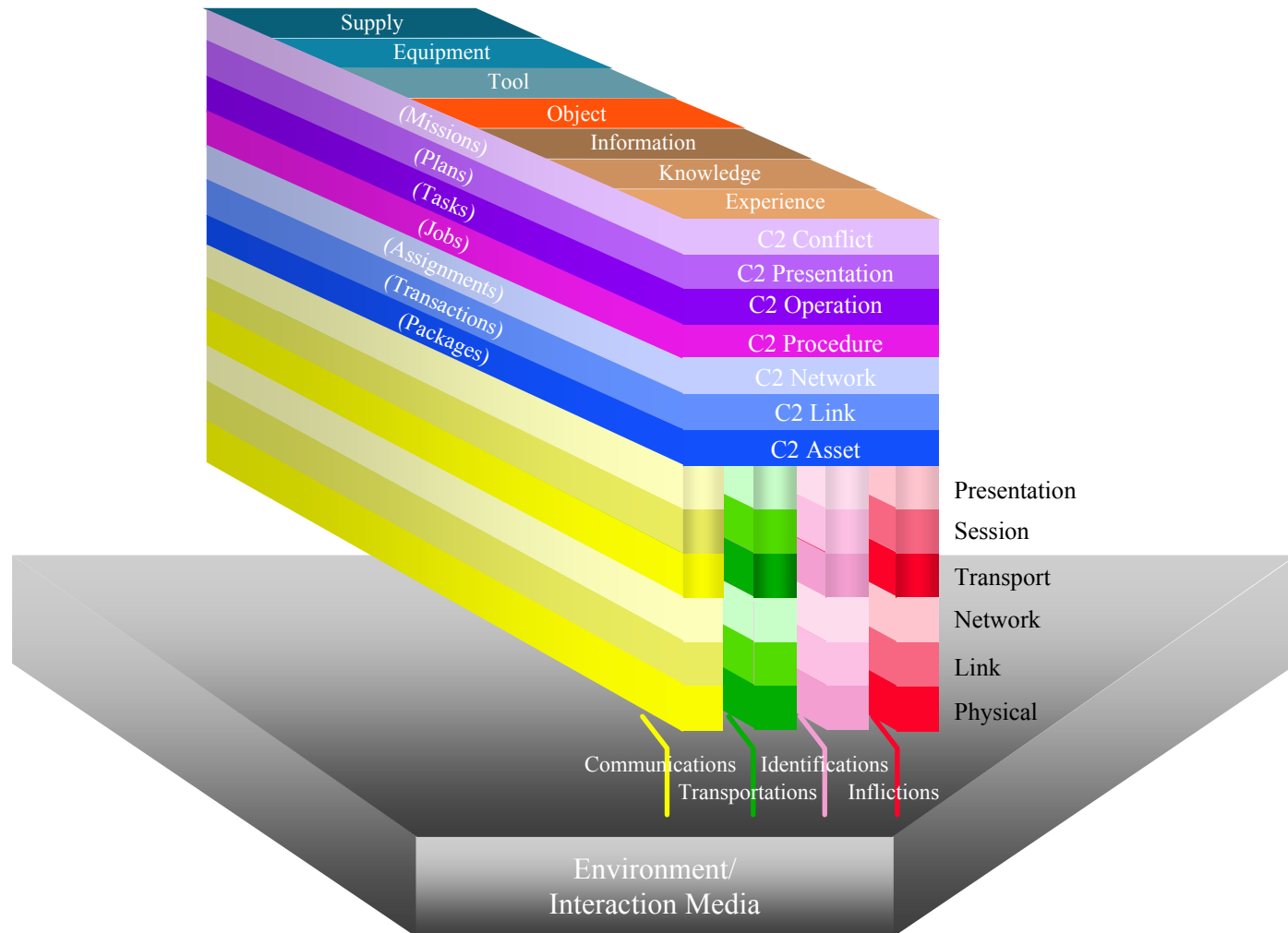


**Technology-Implementation
Domain
{Technical & System}**



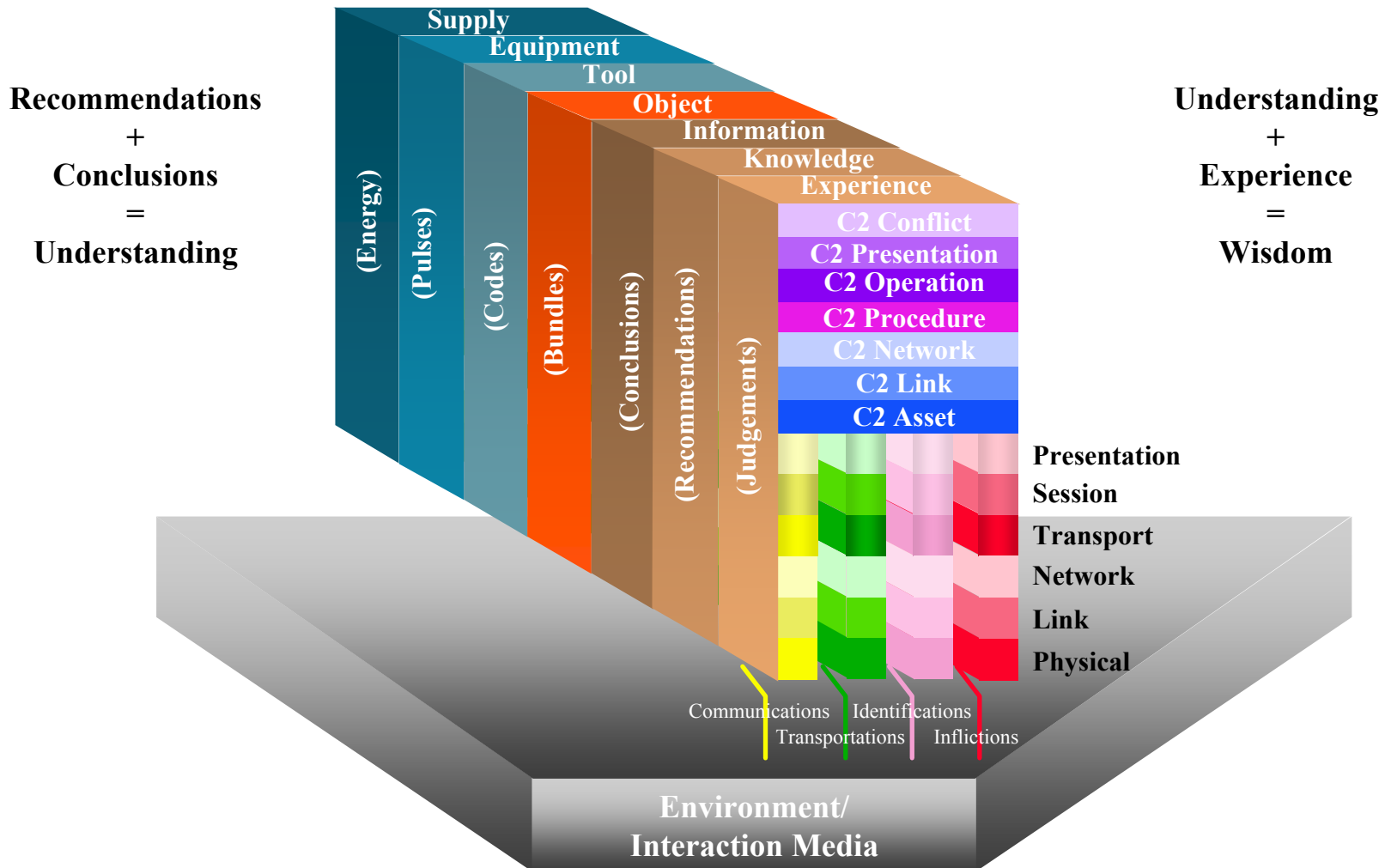
F32a. Inserting technology into C2 apps

- A C2 perspective



F32b. Inserting C2 into existing technology

- A technology perspective



TAnB1. C2RM Key Words

- **Coherent, Consistent Taxonomy**

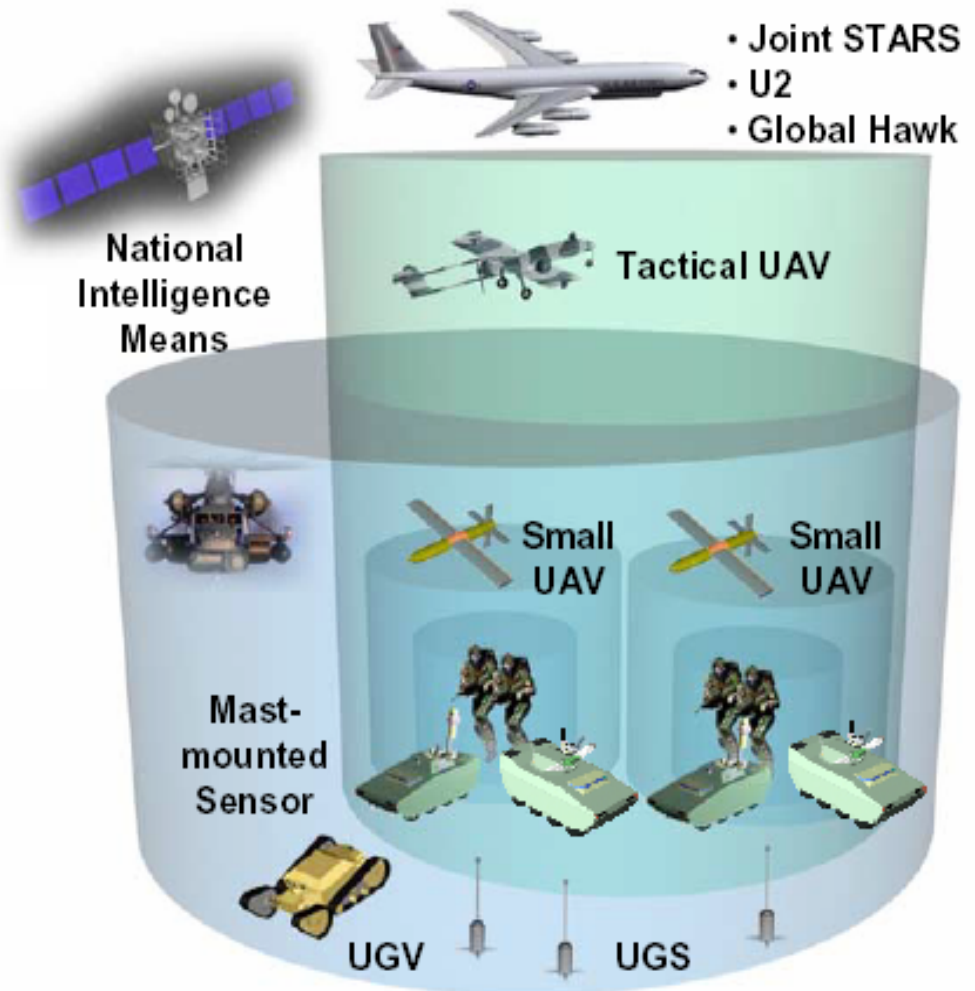
Port:	Physical, Link, Network, Transport, Session, Presentation, Application
Interaction:	Communications, Transportations, Identifications, Inflictions
Official:	Operator, Coordinator, Administrator, Agent, Controller, Planner, Commander
Method:	Instruction, Technique, Discipline, Schema, Tactic, Strategy, Policy
Leader/Commander:	Expert, Partner, Captain, Manager, Director, General, President
Product/Requirement/Fact:	Package , Transaction, Assignment, Job, Task, Plan, Mission
Conflict:	Armament, Engagement, Combat, Battle, Campaign, War, Peace
Representation:	Energy, Pulse, Code, Bundle, Conclusion, Recommendation, Judgment
Base:	Supply, Equipment, Tool, Object, Information, Knowledge, Experience
C2 Application:	Asset, Link, Network, Procedure, Operation, Presentation, Conflict
Organization Module:	Item, Component, Entity, Element, Resource, Unit, Enterprise
C2 Service:	Environm't, Friend, Foe, Relative, Requir'm't, Generat'n, Evaluat'n, Specificat'n
C2 Modes:	Assess, Develop, Monitor
Package:	Ordnance, Image, Message, Cargo
Problem/Solution (C2) Domain:	Command, Center, Staff, Applicat'n , Service , Utility, Facility
Implementat'n/Technology Domain:	Setting, Session, Phase, Base , Service , Utility, Facility
Services:	Display, Enter, Process, Store, Flow
Scenario:	Scenario, Snapshot, Overlay, Cell, Cr_object
Conflict Region (Cr) Object:	Unit, Coordination, Environment
Statement elements:	Who(source), What(action), Whom/Which(target), When, Where, How, Why(outcome)

Network-Centric Battlespace

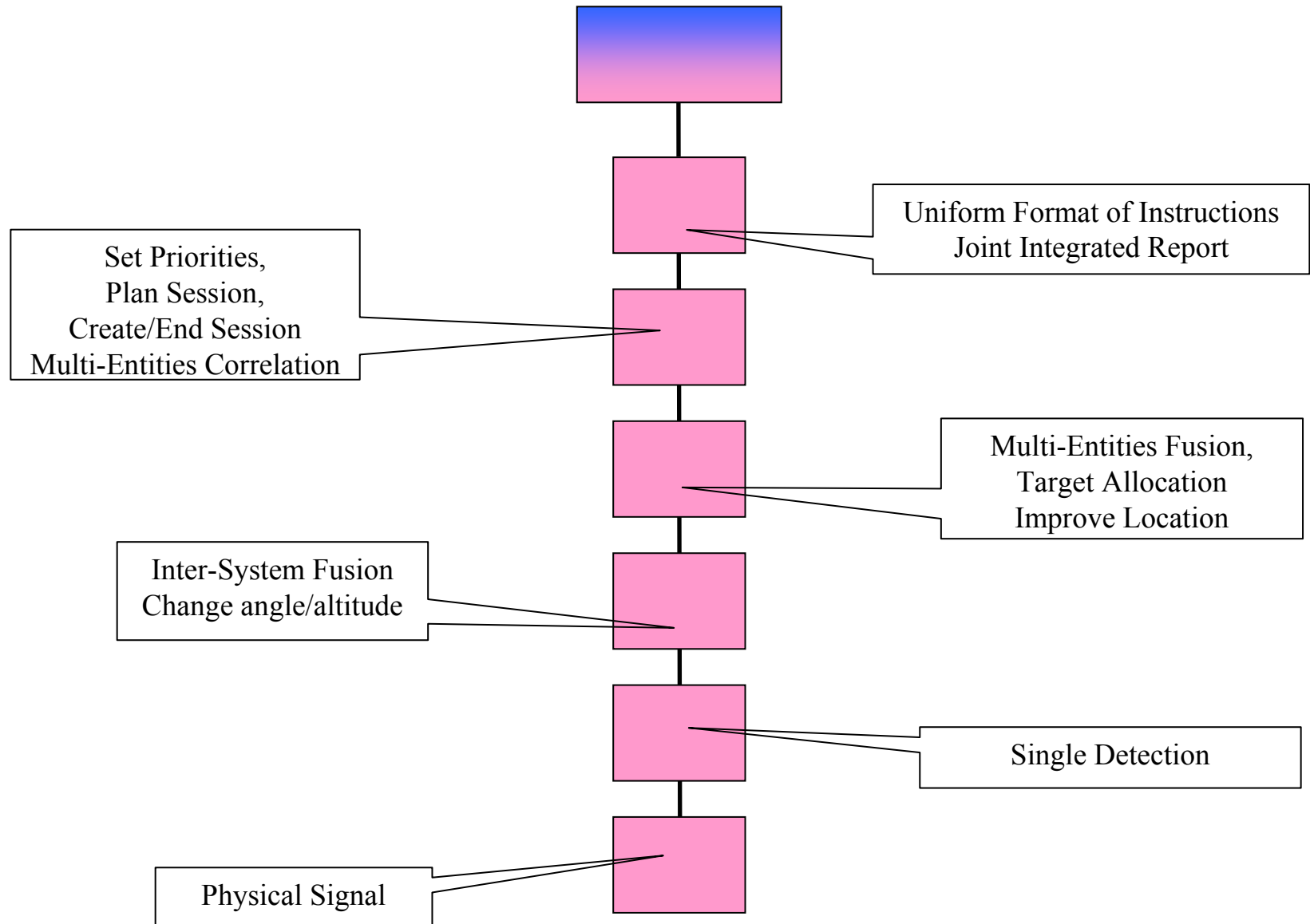
The Massive amount of Reconnaissance and Surveillance assets forces distributed control, distributed processing and semi-autonomous collaboration between the assets.

The goals are:

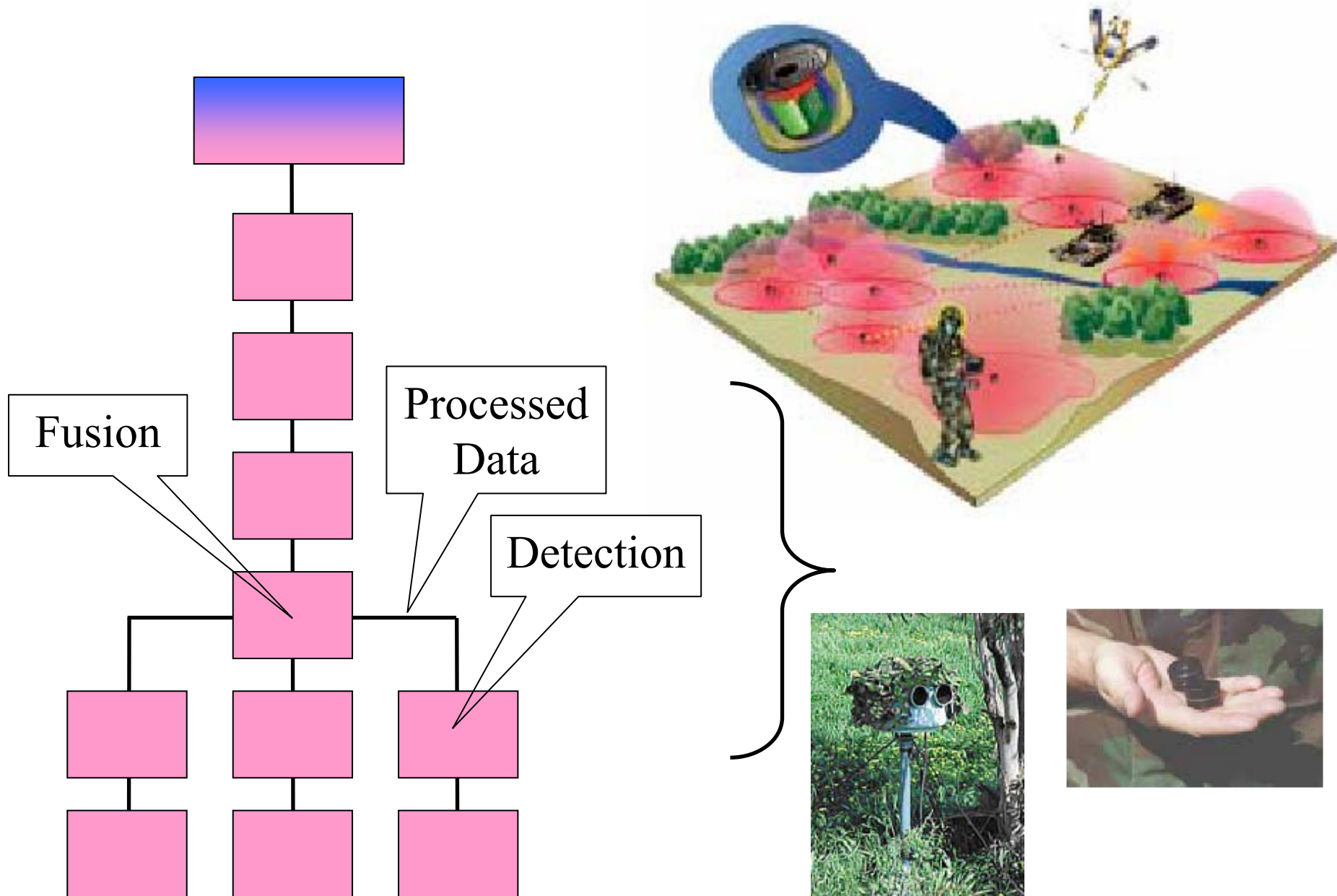
1. Only Identified and Verified objects emerge.
2. Efficient deployment of the Sensors.
3. Reduced number of errors and false alarms.
4. Saving bandwidth.



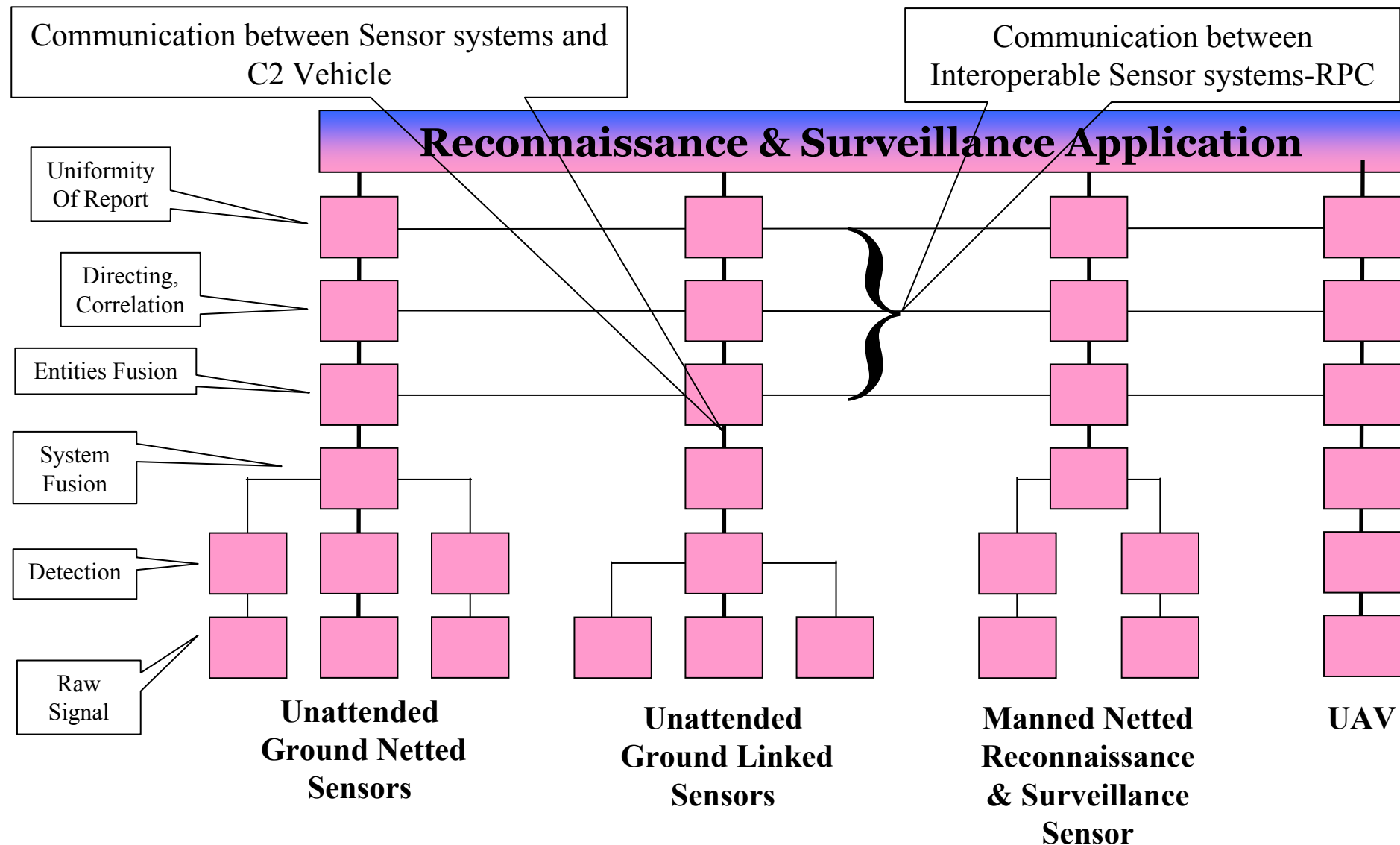
Identification Asset



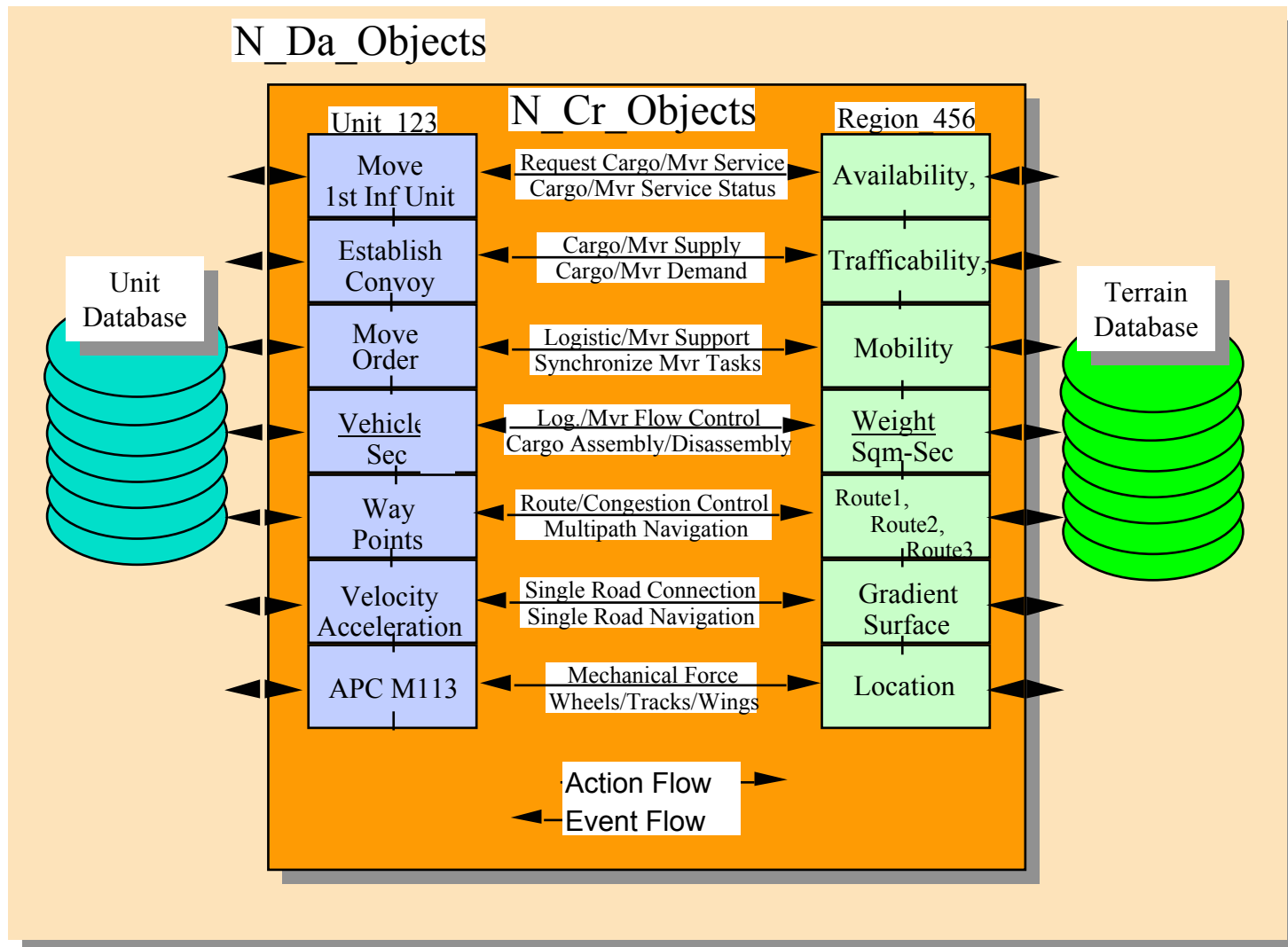
Unattended Ground Netted Sensors



Layered Multi-Sensor Integration



Cr_object Layered_interaction



Hierarchical Use Cases Views

Use-cases Views
per Use-Case.

Mission Level
Views

Task Level
Views

There are four
different types of
ports, but there
may be a few of
each kind.

C2App Level
Views

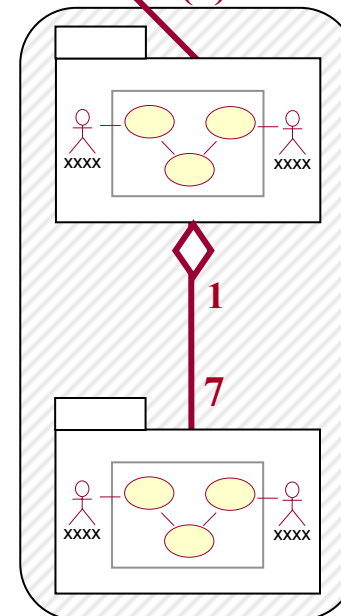
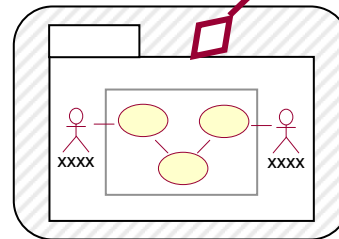
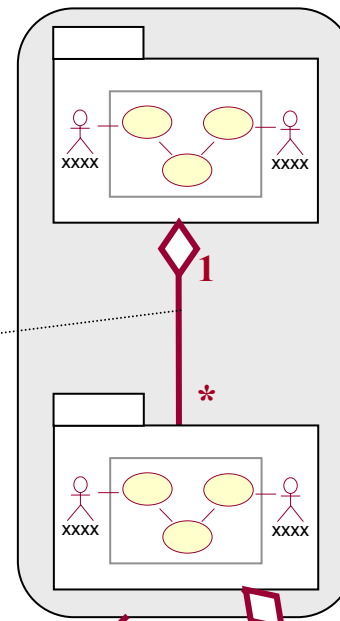
PortApp Level
Views

PortLayer Level
Views

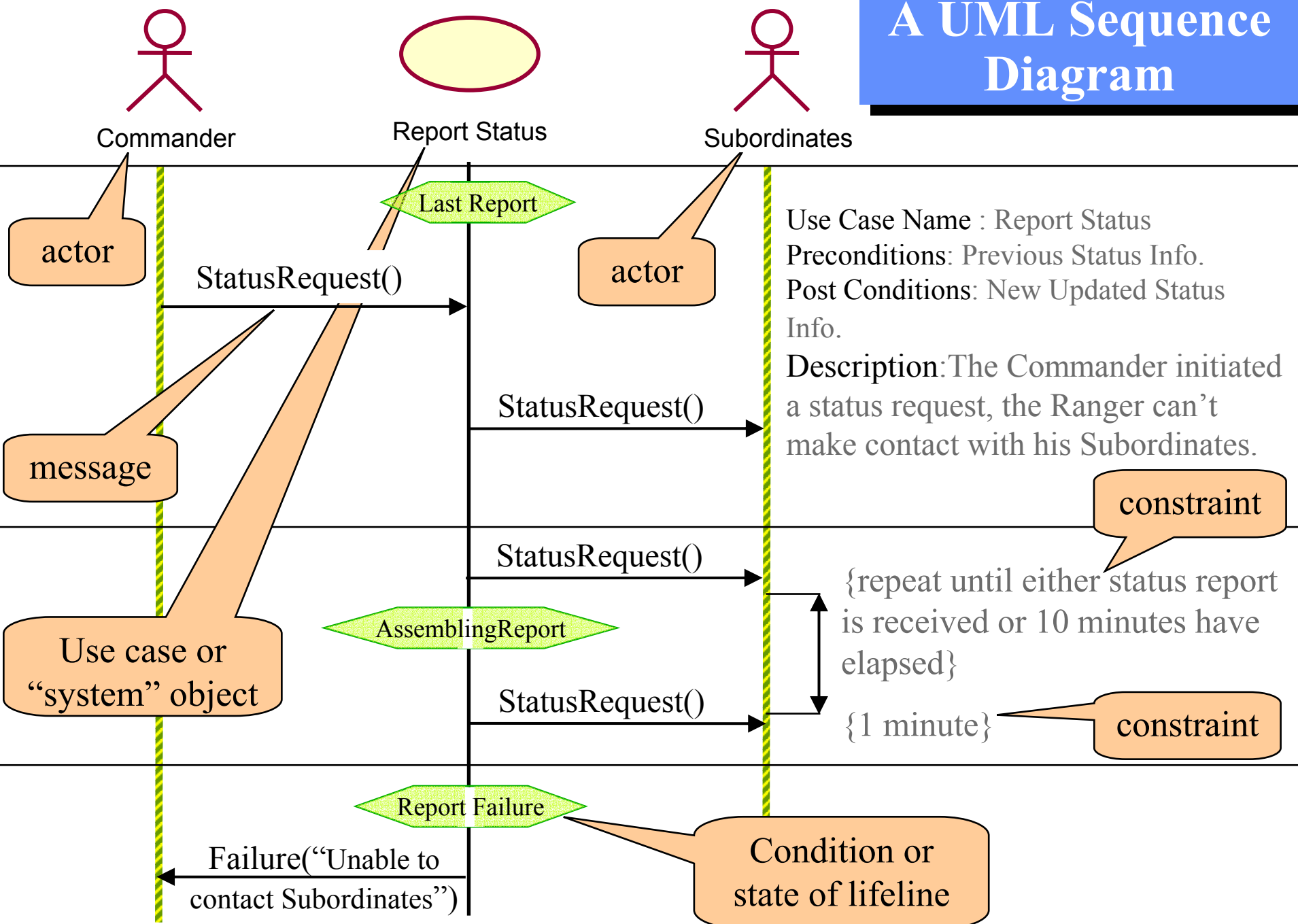
System

Subsystem

Package of
“use-cases views”

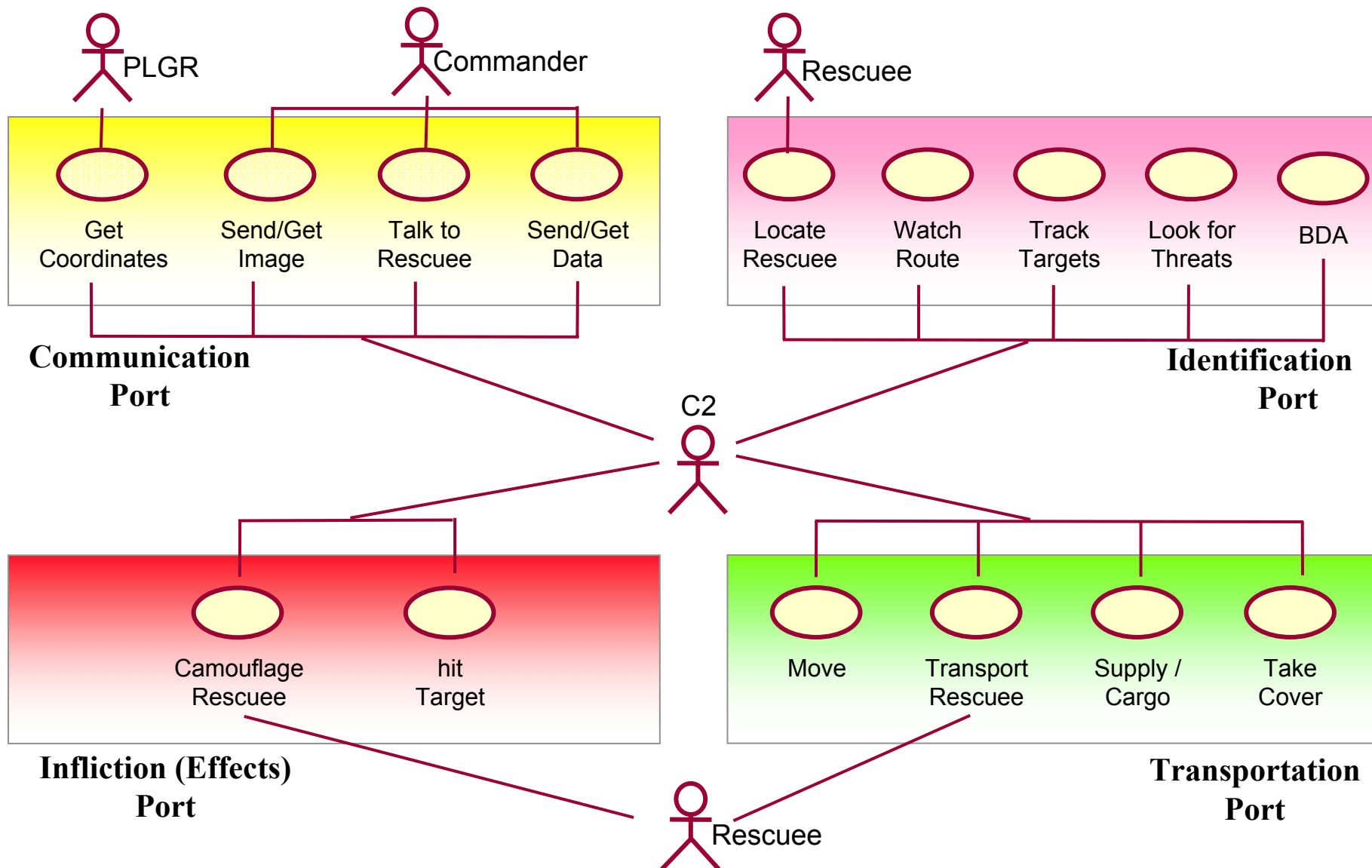


A UML Sequence Diagram

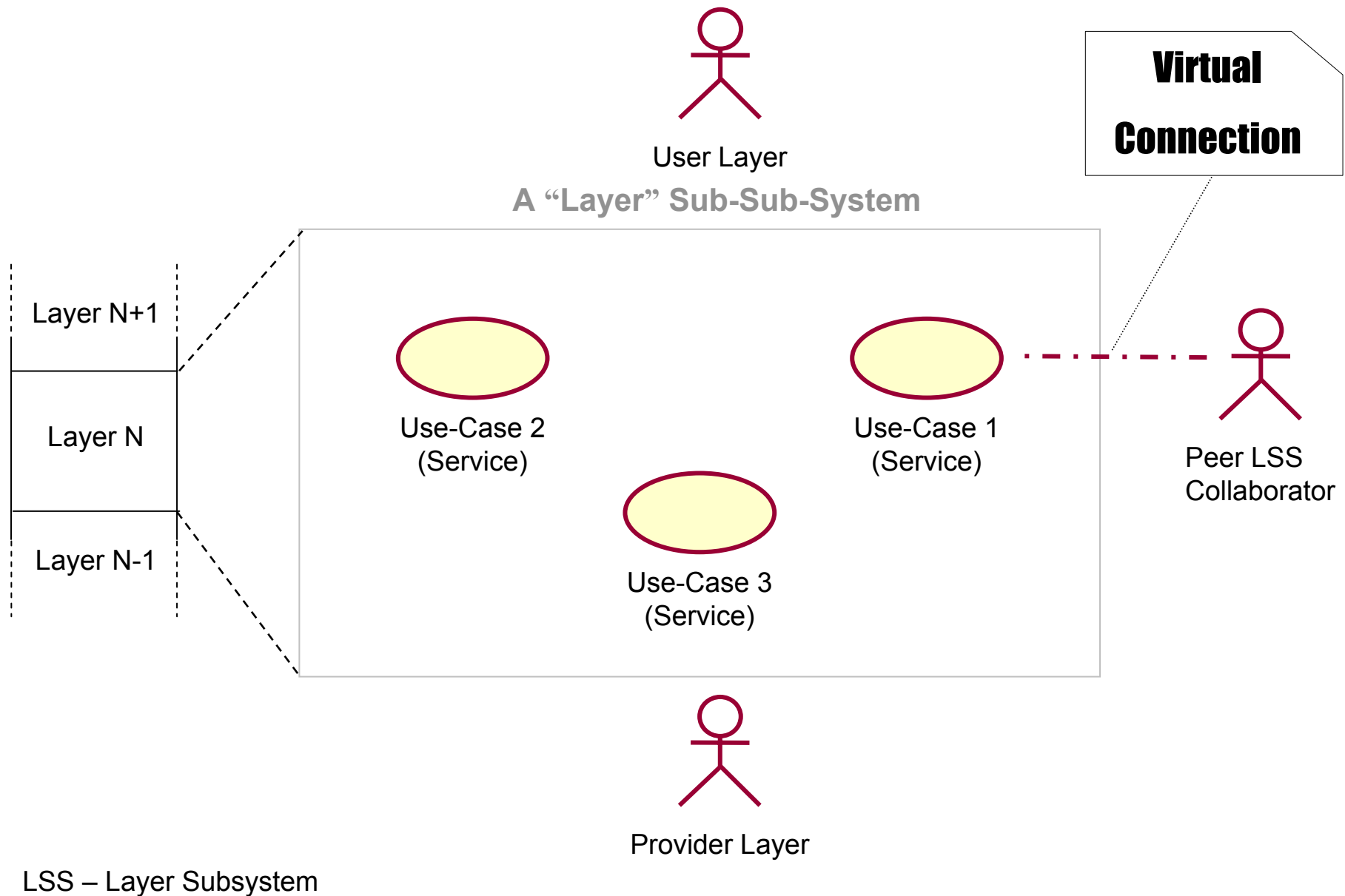


Warfighter Ports Use Cases

(Example)

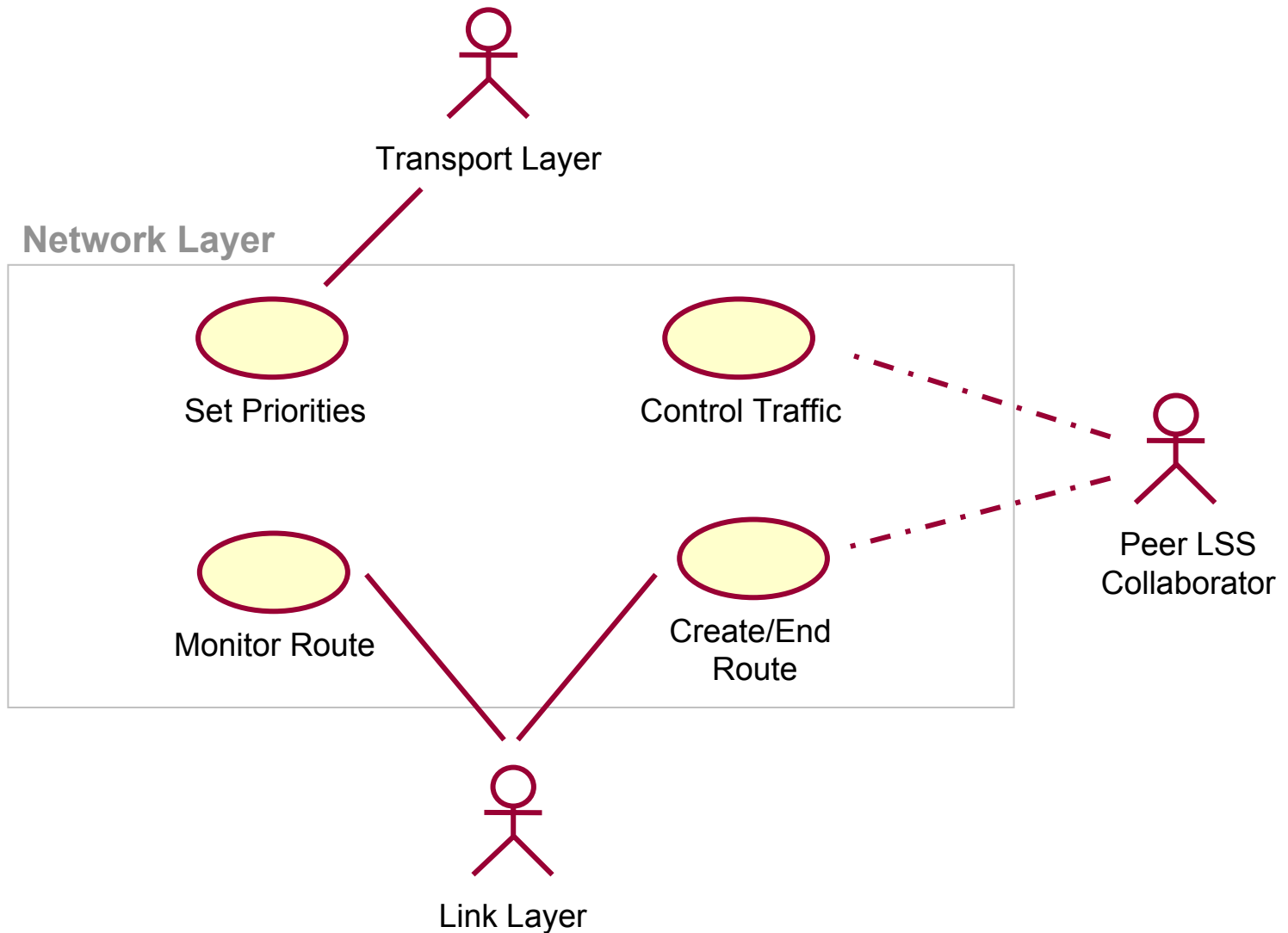


Zoom-in on a Typical Layer



LSS – Layer Subsystem

Communication Network Layer



LSS – Layer Subsystem

Layered Port Classes and Subclasses

GENERAL PORT

Joint Integrated Report

Synchronize user tasks

Set Priorities / Plan Session

Flow Control

Resource Allocation

Position Control

Track Connectivity

Operate

Identification

ISR Data

ICD/IFF

BD.A

Multi-Entities Fusion

Classify/Verify

Multi-Sensor Correlation

Single Detection

Power Sensor

Communication

Encryption

Compression

Enable logon,
Establish QoS

Assemble/Disassemble
Packets

Route Connection

Traffic Control

Single Hop Connection

Power Radio

Infliction

Effect Data

Authorize Weapon
Establish Possible Effect

Match Munitions
to Desired Effects

Assign Fire Nodes

Aim / Guide

Control Fire Tempo

Arm Weapon

Transportation

Supply Data

Cargo Supply/Demand
Monitor Unit's Location

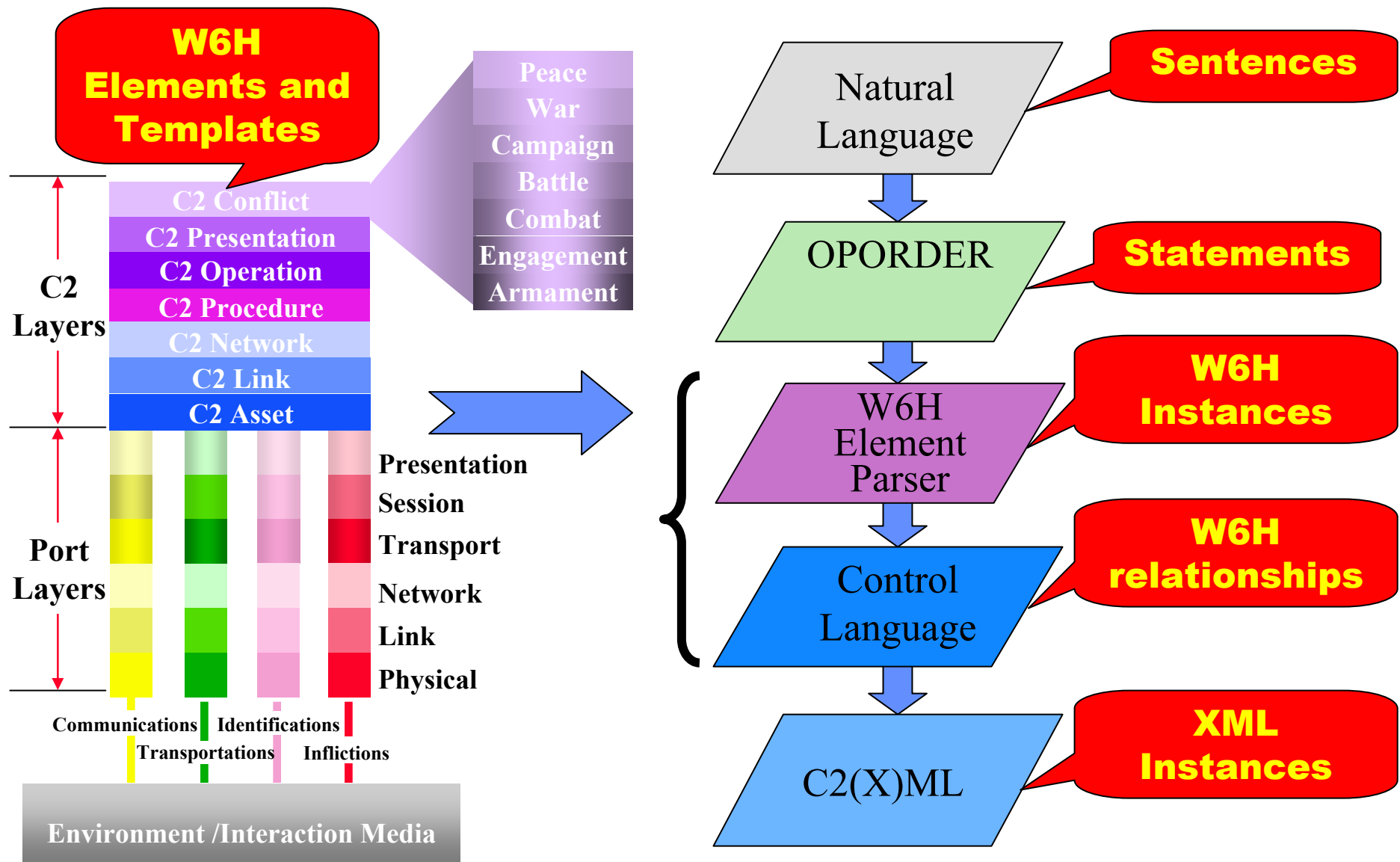
Assemble/Disassemble
Cargo

Route Connection

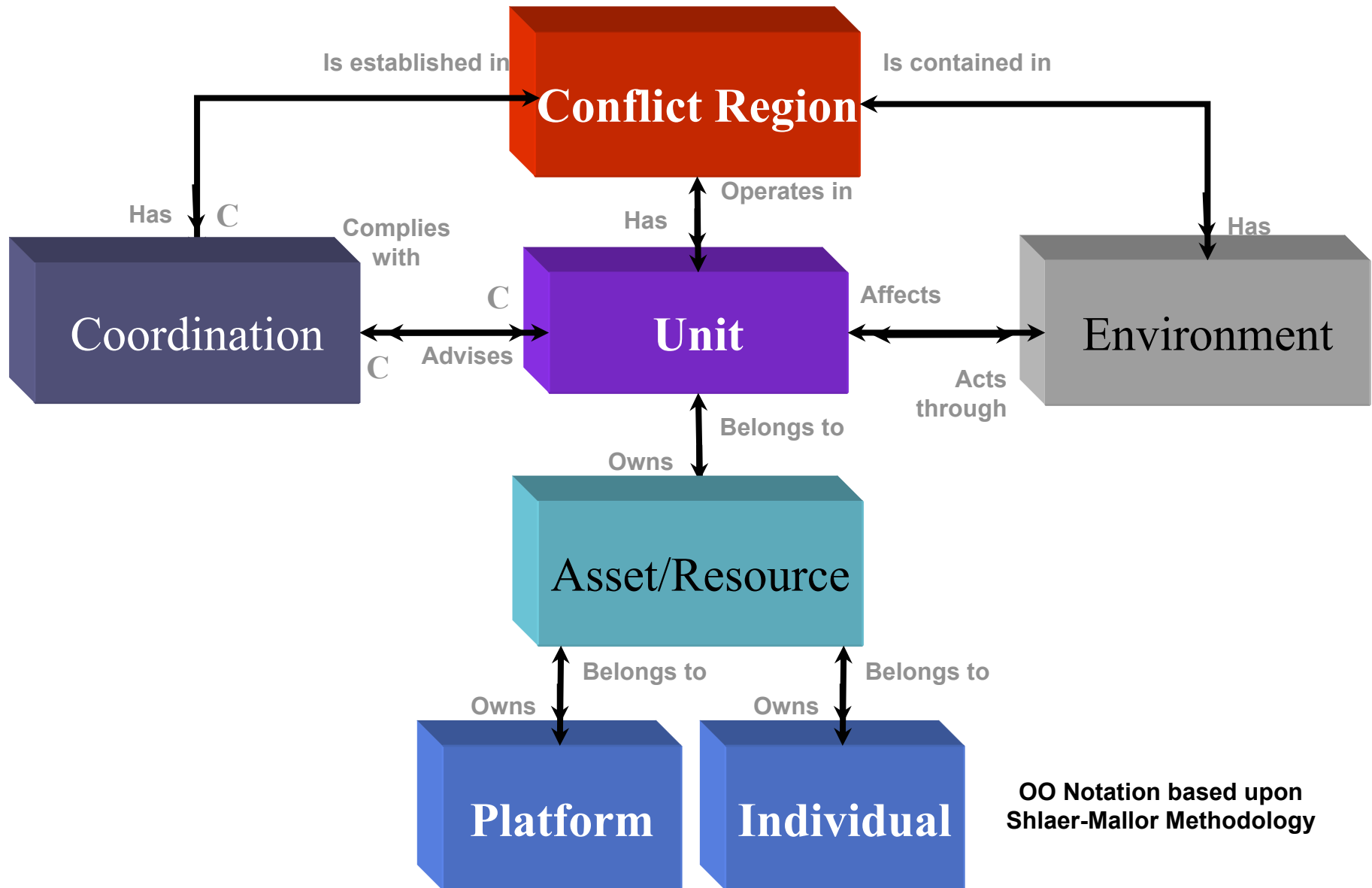
Single Road Navigation

Fuel Vehicle

Formalizing C2 Products

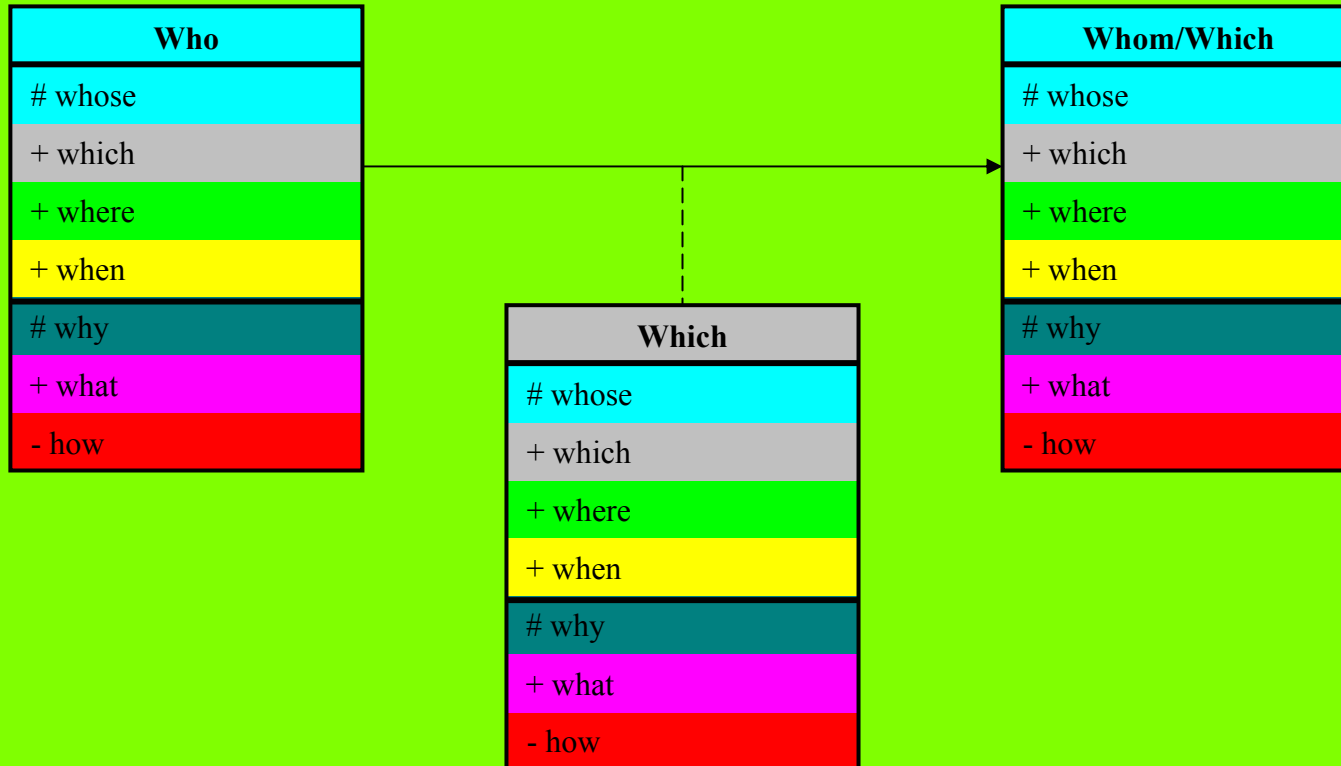


OO Conflict Region Information Model



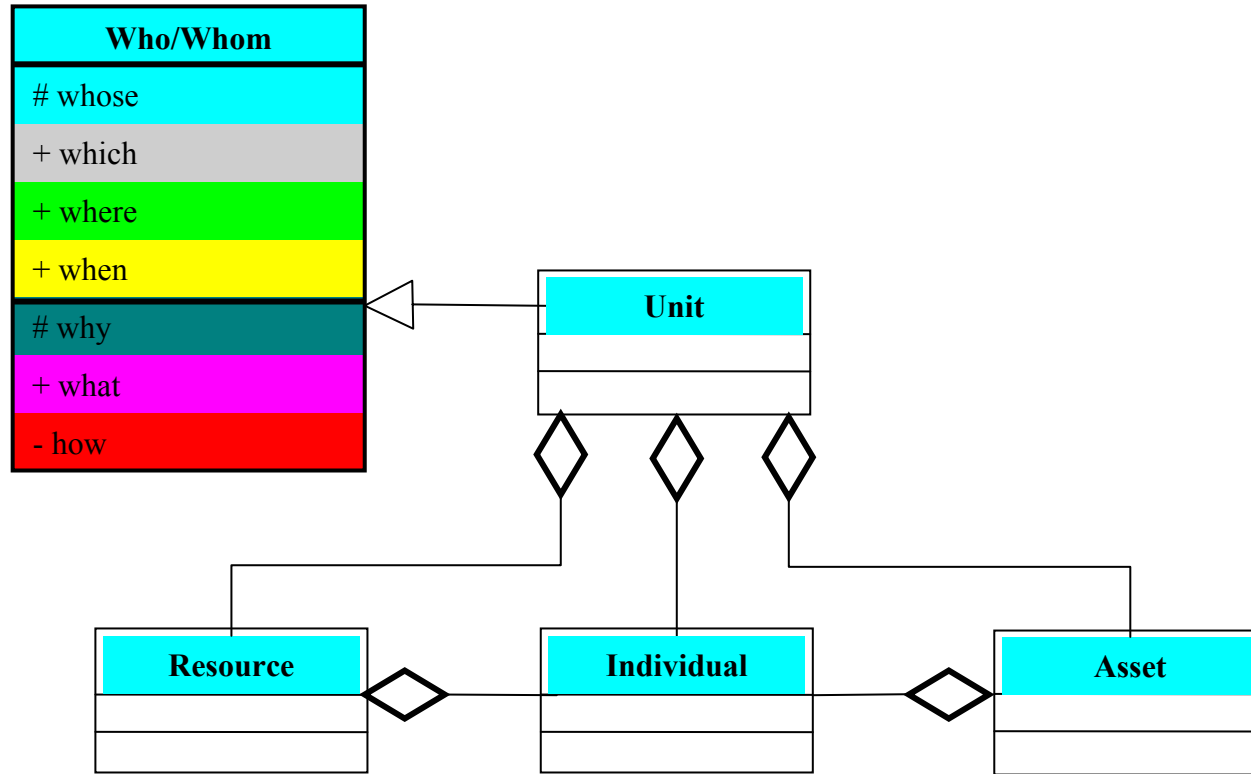
W6H Class Diagram

when

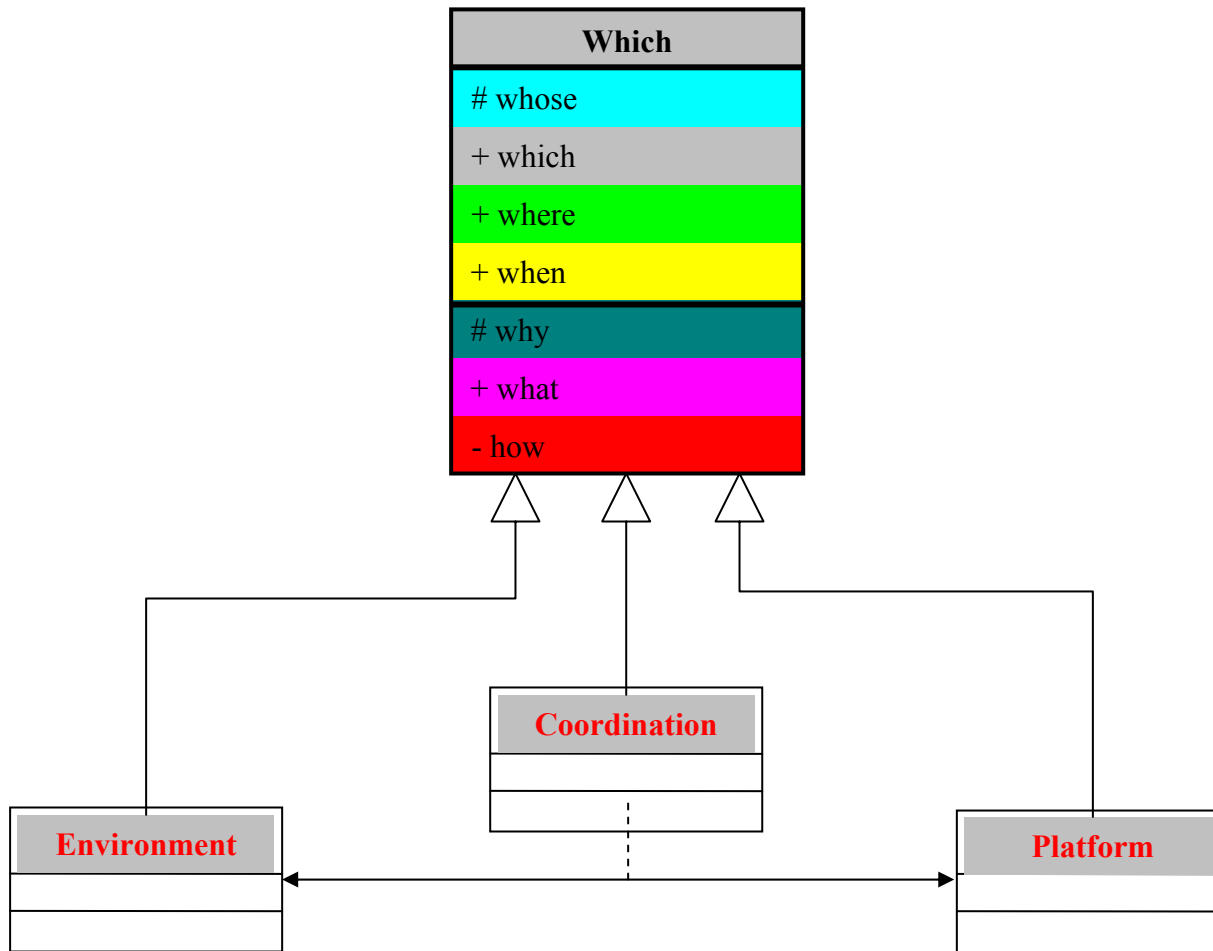


where

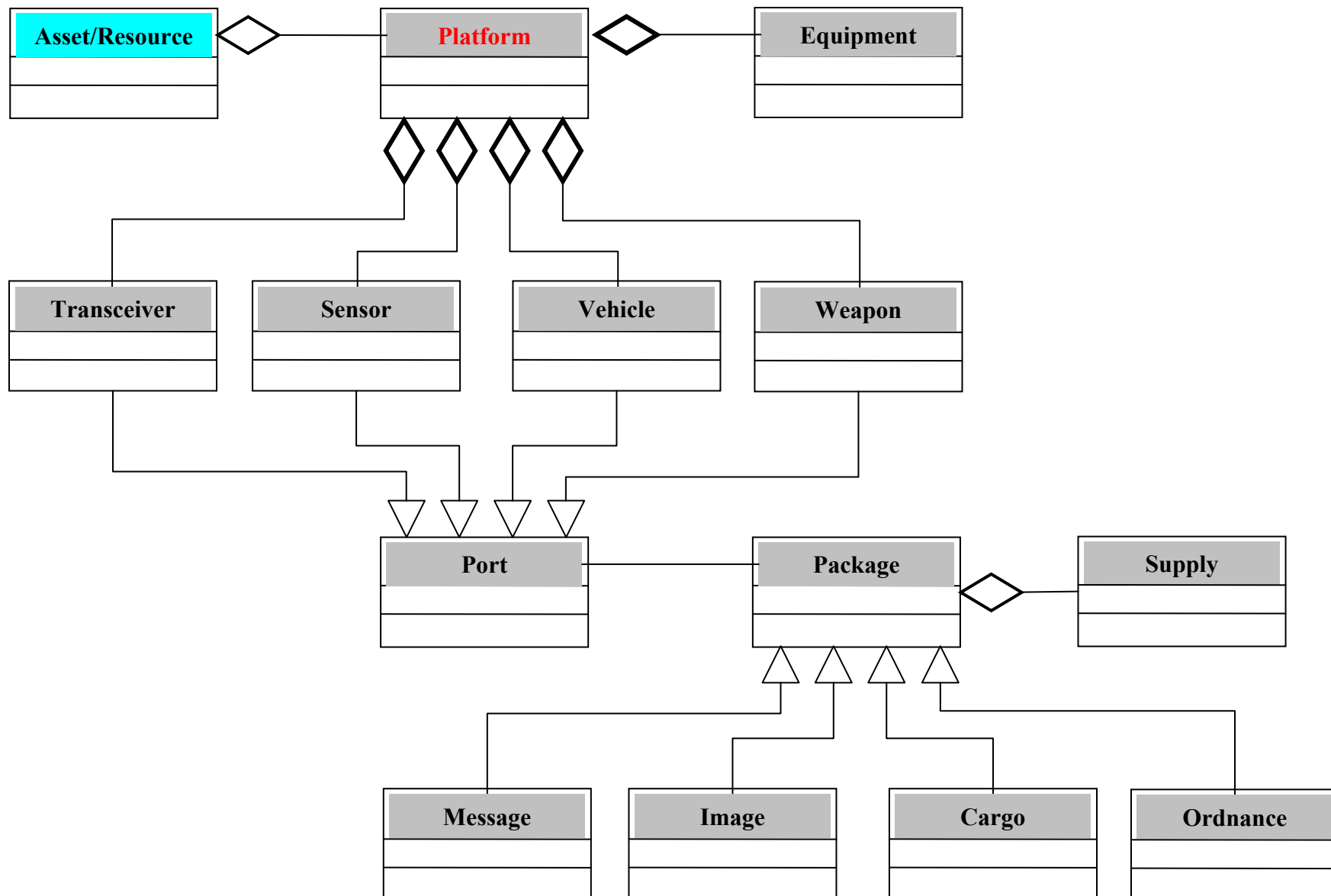
The “Who” / “Whom” Class



The “Which” Class

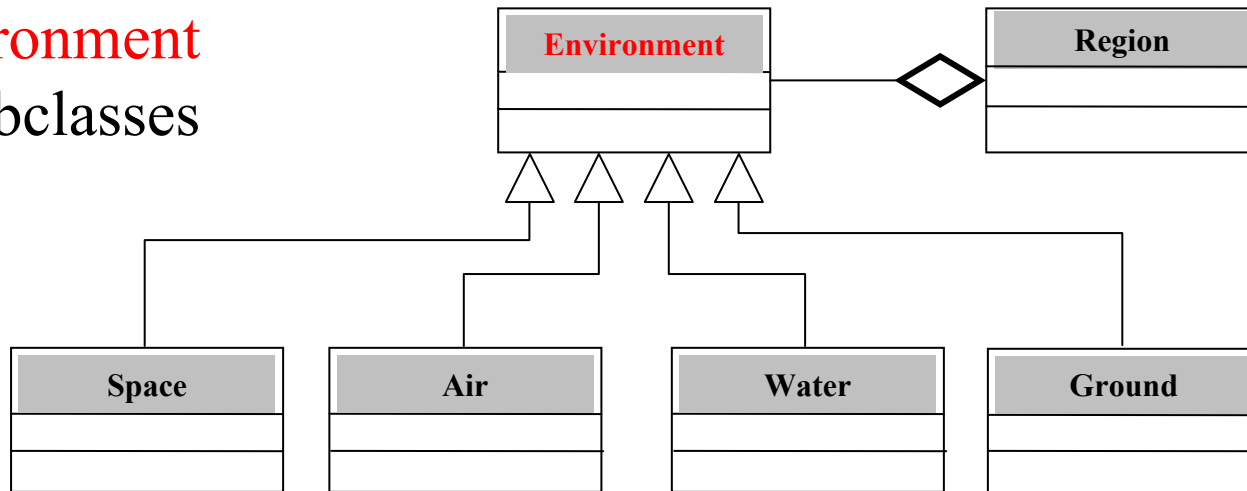


The “Which” Platform Subclasses

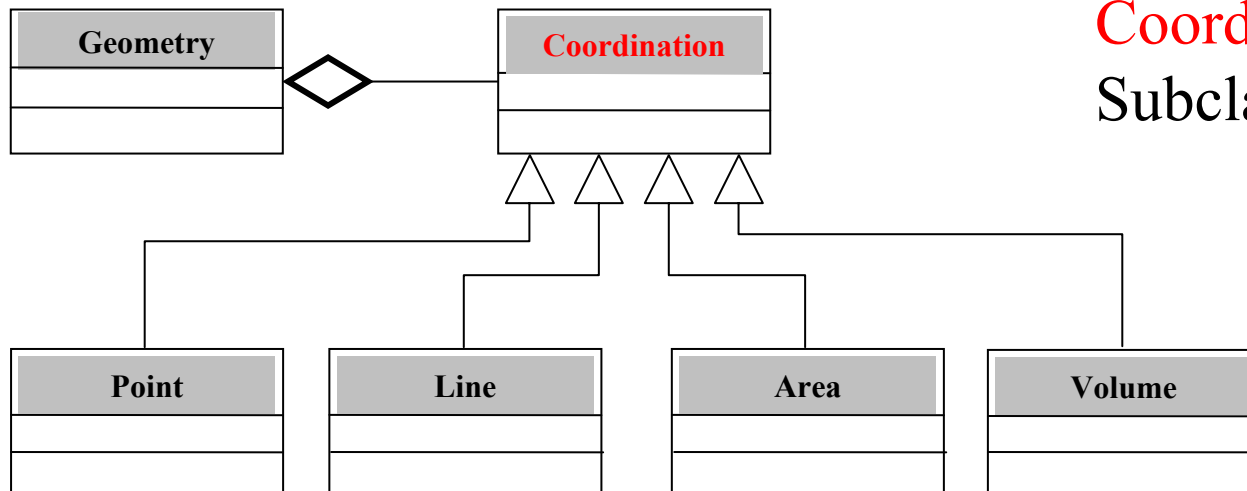


The Other “Which” Subclasses

Environment Subclasses



Coordination Subclasses



Control Language for C2 Products

Control Language Definition

Control Language is made of simple sentences(associations) using 2 or more W6H Elements constructs. There are two types of constructs: Main and Supplemental

* **Main Constructs** includes all W6H elements **at most one time**.

Who (does) **what** (action) (to) **whom** (with) **which**, **where**, **when**, **why** and **how**.

* **Supplemental Constructs** are derived using UML-based Domain Object statements:

Which W6H element is **included** in which other W6H element?

Which W6H element is **extended** by which other W6H element?

Which W6H element is a **generalization/specialization** of which other W6H element?

Which W6H element is an **aggregate (shared/composite)** of which other W6H element?

Which W6H element is **equivalent** to which other W6H element?

Commander's Intent Example W6H Relationships

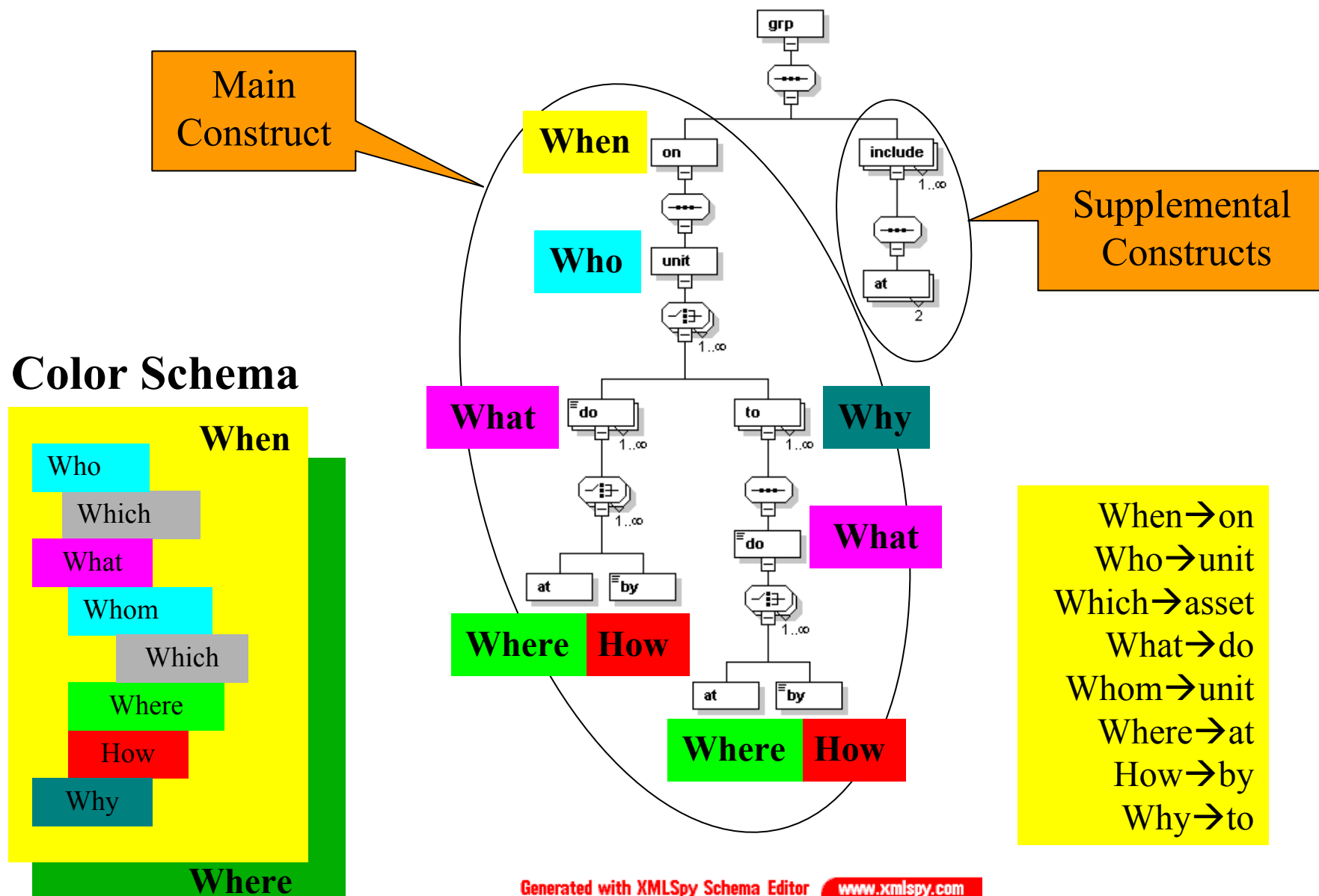
Who(1st Armored Brigade) **What**(destroy) **Whom** (enemy) **Which** (using minimum force)

Where (in objective area) **When** (on order)

Why (to ensure safe forward passage by 21st Infantry Division)

How (immediate, wedge formation,)

An XML Schema Using W6H Constructs



Singly-Nested Main Statement Elements Constructs Schemata

When (for a given statement)

Where (for the given When)

Who (is at the given When)

What (occurs at the given When)

Whom (is at the given When)

How (the When is bounded and subdivided)

Why (use the given When)

Who (for at the given When)

When (for the given Who)

Where (is the Who)

How (does the Who implements the What)

Why (use this particular Who)

What (occurs for the given When)

When (for the given What)

Where (is the What)

How (is the What affected by the Where)

Why (use this particular What)

Whom (for the given When)

When (for the given Whom)

Where (is the Whom)

How (is the Whom affected by the What)

Why (use this particular Whom)

Where (for the given When/Who/What/Whom)

How (is the Where bounded and subdivided)

Why (use this particular Where)

How (for the given When/Where/Who/What/Whom)

Which (parts are used for this particular How)

Why (use this particular How)

Why (use this particular When/Where/Who/What/Whom/How)

Which (reason is applicable for this Why)

Identifying W6H Elements in OORDER

OORDER Excerpt

On order IBCT deploys to MACRAN REPUBLIC and moves immediately to Kazar to secure the KACANIC CORRIDOR, PRISTINA Airfield, and PRISTINA, and to establish a US presence throughout the zone



W6H Elements	W6H Metadata
Who /whom/whose:	unit, resource, asset, individual
What (do):	action, plan, operation, task, mission, results, status, outcome
Which (object/product):	platform, equipment, supply, system, package(messages, images, cargo, ordnance)
Where (at):	place, vicinity, coordinates, region, location, position
When (on):	datetime, event, before, after, during, parallel, sequential, o/o
Why (to):	purpose, goal, objective
How (by):	organization, formation (arrangements of forces for specific purposes), command relationship (degree of control responsibility), timing



W6H Elements for OORDER Excerpt

On order IBCT deploys to MACRAN REPUBLIC and moves immediately to Kazar to secure the KACANIC CORRIDOR, PRISTINA Airfield, and PRISTINA, and to establish a US presence throughout the zone

Transforming Natural Language to Control Language

W6H Elements for OPCODE Excerpt

On order IBCT deploys to MACRAN REPUBLIC and moves immediately to Kazar to secure the KACANIC CORRIDOR, PRISTINA Airfield, and PRISTINA, and to establish a US presence throughout the zone

W6H General rules:

Each sentence is composed of a set of W6H elements. Each complex W6H element may be decomposed into W6H sub-elements. Iterate W6H rules for each complex W6H element. Apply template/logic to relate between W6H elements and sub-elements. Apply template/logic to relate between abstract references and concrete context.

W6H Element rules:

Find conjunctions and separate complex sentences into simple sentences. Find pronouns and substitute names from context. Identify non-essential background information. Find noun phrases to identify **who** and **whom**. Find verb phrases to identify **what** actions are taken. Look for the temporal phraseology (time) to extract **when**. Look for spatial phraseology (places) to extract **where**. Identify **how** for each **what** if any. Find goal phrases by looking for “to” “for” “because” and other “rationale” phraseology to identify **why**.

W6H Association Rules:

Associate lower-level W6H sub-elements with higher corresponding W6H element. Identify the following relationship: Who to Whom, Whom to Who, Who to Which, Whom to Which, Who to What, What to Whom, Who to When, What to When, Who to Where, Where to Where, When to When, Who to Why, What to Why, What to How, etc.

W6H Relationships for OPCODE Excerpt (Control Language)

IBCT is a US unit
On order IBCT deploys to MACRAN REPUBLIC
On order IBCT moves immediately to zone
IBCT secures zone. IBCT establishes presence throughout zone
Zone is in Kazar. IBCT is in zone
Kacanic Corridor is in zone. Pristina Airfield is in zone. Pristina is in zone

Tagging W6H Control Language Constructs

Control Language Constructs	XML tagging applied to Control Language Constructs
IBCT is a US unit	<code><unit type="tactical" name="IBCT" id="1st" role="Combat" size="Bde Team" aff="US" cmps="(+)"/></code>
On order IBCT deploys to MACRAN REPUBLIC	<code><on type="order"/> <do type="task">deploy</do> <at type="state" name="MACRAN REPUBLIC" associate_do="arrive"/></code>
On order IBCT moves immediately to zone	<code><do type="task">move</do> <by type="rate">immediately</by> <at type="zone" name="" associate_do="arrive"/></code>
IBCT secures zone	<code><to><do type="task">secure</do> <at type="zone" name="" /> </to></code>
IBCT establishes presence throughout zone	<code><to><do type="task">establish presence</do> <at type="zone" name="" /> </to></code>
zone is in Kazar	<code><include><at type="zone" name="" /><at type="region" name="Kazar"/></include></code>
KACANIC CORRIDOR is in zone	<code><include><at type="corridor" name="KACANIC"/><at type="zone" name="" /> </include></code>
PRISTINA Airfield is in zone	<code><include><at type="airfield" name="PRISTINA"/><at type="zone" name="" /></include></code>
PRISTINA is in zone	<code><include><at type="city" name="PRISTINA"/><at type="zone" name="" /></include></code>

Resulting XML Instance of OPCODER Excerpt

(Expanded Form)

```
<?xml version="1.0" encoding="UTF-8"?>
<grp type="Situation/Friendly Forces" fnc="Mission">
  <on type="order">
    <unit type="tactical" name="IBCT" id="1st" role="Combat" size="Bde
Team" aff="US" cmps="(+) ">
      <do type="task">deploy<at type="state" name="MACRAN REPUBLIC"
associate_do="arrive"/>
      </do>
      <do type="task">deploy<by type="rate">immediately</by>
      <at type="zone" name="" associate_do="arrive"/>
      </do>
      <to>
      <do type="task">secure<at type="zone" name="">
      </do>
      </to>
      <to>
      <do type="task">establish presence<at type="zone" name="">
      </do>
      </to>
    </unit>
  </on>
  <include>
    <at type="zone" name="">
    <at type="region" name="Kazar"/>
  </include>
  <include>
    <at type="corridor" name="KACANIC"/>
    <at type="zone" name="">
  </include>
  <include>
    <at type="airfield" name="PRISTINA"/>
    <at type="zone" name="">
  </include>
  <include>
    <at type="city" name="PRISTINA"/>
    <at type="zone" name="">
  </include>
</grp>
```

Conclusions

- **UML is a viable and robust meta-model for all Object-Oriented models**
- **UML can be represented effectively in XML**
- **The C2 domain is inherently Object-Oriented**
- **UML is a viable and robust meta-model for C2 architectures and applications**
- **C2 Applications and architectures can be represented effectively in XML**
- **C2RM is needed as viable and robust meta-model for all C2 UML models and applications and all C2 XML representations**
- **C2 metadata registries will be more effectively utilized if they are designed to correspond to a robust C2 meta-model such as the C2RM**

For More Information

Dr. Israel Mayk, CERDEC

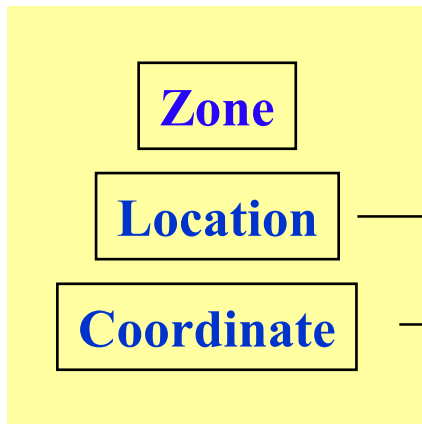
US Army Communications-Electronics Command (CECOM),

Research, Development and Engineering Center (RDEC)

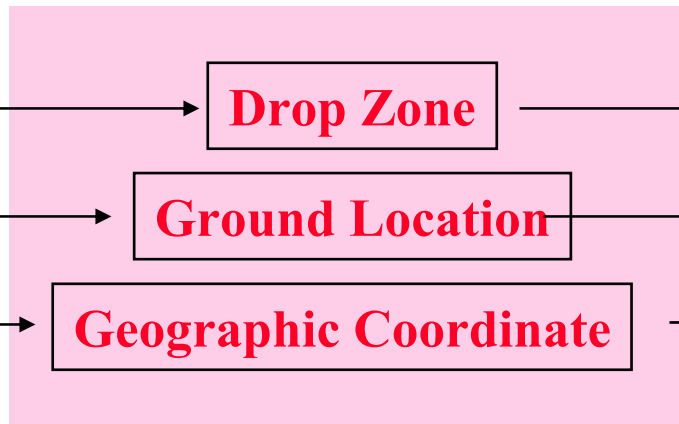
israel.mayk@us.army.mil

Inter-relating ISO 11179 Concepts and Domains

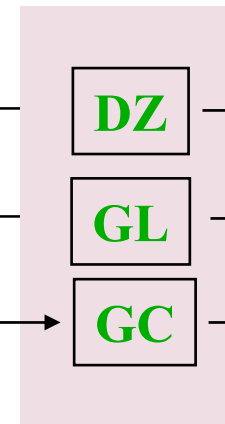
DE Concepts:



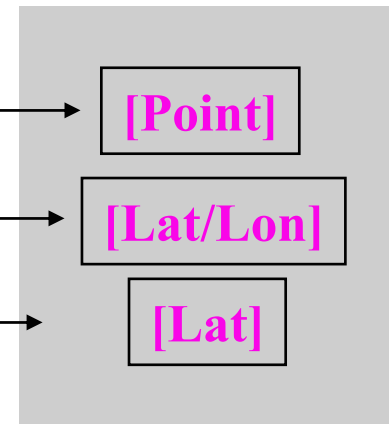
Concept Domains:



DEs:



Value Domains:



DE Concept: The Data Field / Variable, eg: Zone

Concept Domain: The Data Use / Context, eg: Drop Zone

DE: the Data Field Identifier / Name / Symbol, eg: “DZ”

Value Domain: [Point]

DE Concept: The Data Field / Variable, eg: Location

Concept Domain: The Data Use / Context, eg: Ground Location

DE: the Data Field Identifier / Name / Symbol / Label, eg: “GL”

Value Domain: [Lat/Lon]

DE Concept: The Data Field / Variable, eg: Coordinate

Concept Domain: The Data Use / Context, eg: Geographic Coordinate

DE: the Data Field Identifier / Name / Symbol, eg: “GC”

Value Domain: [Latitude]

Information Architecture for Unit Status

